QUARTERLY BULLETIN No. 8

MARCH 1955

ISSUED: BY

THE BRITISH SULPHUR CORPORATION LTD.,
4, GRAFTON STREET,
LONDON, W.1.

Telephones : HYDE PARK 8989
GROSVENOR 5606

Telegrams : SULFEX, PICCY, LONDON

Cables : SULFEX, LONDON

Printed by The Essex Chronicle, Chelmsford, England

CONTENTS

	PAGE
Foreword	1
Review	1
The Sulphur Industry of the United Kingdom	4
Pyrites and Sulphuric Acid in Japan	14
Prices and Trends	20
United States Sulphur	22
Jefferson Lake Sulphur Company	25
Off-Shore Sulphur	27
Sulphur in Italy	28
The Sulphuric Acid Industry in Poland	29
Sulphur in O.E.E.C. Countries	31
Sulphuric Acid Production from Hydrogen Sulphide	33

CURRENT EVENTS:

U.K.	Acid Plant Construction	39
Canada	Recovered Sulphur	39
Union of South Africa	New Acid Plant	39
U.S.A.	Freeport Sulphur Company	40
	Continental Sulphur and Phosphate Corporation	40
	Insoluble Sulphur	40
Denmark	Recovered Sulphur Potential	41
Italy	Sulphur Refining Process	41
Mexico	Gulf Sulphur Corporation	41
Ecuador	Ecuadorian Mining Corporation	42
Iraq	Sulphur Concession	42
India	New Sulphur Deposits	42
	Pyrites Discovery	42

INDEX TO ADVERTISERS:

Biddle Sawyer & Co., Ltd.	*vi*
Courtaulds Ltd.	*ii*
Fisons Ltd.	*iii*
International Sulphur Corporation	*v*
Jefferson Lake Sulphur Corporation	*v*
Mexican Gulf Sulphur Company	*v*
Simon-Carves Ltd.	*iv*
The Power-Gas Corporation Ltd.	*i*

FOREWORD

THE EIGHTH ISSUE of the *Quarterly Bulletin*, which marks the completion of two years' increasingly successful production, introduces two innovations—printing and the inclusion of advertisements. The improved presentation of text and illustrations should make the *Bulletin* more attractive to readers, particularly those who receive the air mail edition. It is hoped that the advertising service may appeal to subscribers, on account of the *Bulletin's* exclusive character, and the fact that its circulation takes it into the hands of top level executives. Enquiries as to details of this service will be welcomed, and should be addressed to this office.

The last issue of the *Bulletin*, No. 7, contained an Appendix, "Free World Sulphur Survey," for which we were indebted to the Freeport Sulphur Company. As a result of a considerable demand for extra copies of this article, it has been been reproduced and bound separately. Copies may be obtained from this office on payment of Five Shillings each to cover production and despatch. *March, 1955.*

Review

THE sulphur industry of the **United Kingdom,** which, in 1954, consumed over one million tons sulphur in various forms, is the fourth largest in the world, surpassed only by the U.S.A., U.S.S.R., and Japan. Its predominant problem remains the procurement of raw materials, and changes in their type and source have fashioned its pattern. In the absence of indigenous supplies, 89% of the country's total brimstone requirements and practically all its pyrites needs are at present imported to provide more than one-half of the total sulphur usage. The balance is met by the use of native anhydrite, for direct manufacture of ammonium sulphate and increasingly for sulphuric acid manufacture, and by recovery from smelter, coal, and oil refinery gases in the form of acid, spent oxide, or elemental sulphur. The requirements of the sulphuric acid industry, whose output in 1954 exceeded two million tons, are the main factor determining the pattern of supply. As the result of the conversion and new construction programme of 1951, the industry's productive capacity has been increased by about 36% to about 2.7 million tons per annum, and the provision of some alternative roasting facilities afford it a greater measure of flexibility in the types of raw material that it may use. Its most striking effect has been the reduction of the industry's dependence on imported brimstone, although, notwithstanding the increased facilities for the use of indigenous sulphurous raw materials, it has resulted, to-day, in an almost equal balance of dependence on imported pyrites. The removal of Government restrictions on acid-sulphur use, expected by the end of this year, may lead to a fuller use of this raw material at the expense of the less economical—notably pyrites—and so halt the trend of rise in acid prices.

The use of brimstone for industrial (regular) uses, which in 1954 totalled 115,000 tons, is largely determined by the level of activities of the United Kingdom rayon industry, which accounts for over 60% of the tonnage so consumed.

In 1955 the United Kingdom sulphur industry is expected to use 1,130,000 tons sulphur in the form of about 340,000 tons brimstone, 600,000 tons pyrites, nearly 1.5 million tons anhydrite, and over ¼-million tons sulphur recovered from smelter, oil refinery, and coal gases. Although in recent years the consumption of sulphur has increased at a faster rate, past trends indicate that an expansion of total sulphur usage at an annual rate of 3-4% may be expected.

The pyrites industry of **Japan** is to-day the largest in the world, with an annual output approaching 2½ million tons. Based on vast reserves, as yet not fully assessed, of various types of ore, its scope is primarily determined by the country's sulphuric acid industry, which derives 88% of its sulphur requirement from pyrites.

Due to the extensive use of pyritic ores and sulphide concentrates in non-ferrous metal production, the recovery of sulphur in smelter gases, as by-product sulphuric acid, has long been a feature of the industry, and its importance is growing. Elemental sulphur plays only a negligible part in meeting the sulphur needs of the acid industry, since sulphur in pyrites is the cheaper raw material.

Acid consumption, which amounted to over 3 million tons in 1954, is expanding to help solve Japan's two vital problems : food and exports. At present the fertiliser industry accounts for 73% of total acid usage, and Japan's main exporting industries, textiles, metals, chemicals, and dyes, take up 20%. A government-inspired programme provides for a 33% expansion of fertiliser production by 1958, to raise output to 3.2 million tons, and capacity to 3.6 million tons. The development of the pyrites industry depends on its ability to provide increased supplies economically, and greater modernisation and concentration into large units may be expected.

In the **United States of America** production of native and recovered sulphur in 1954, the highest on record, totalled 5,872,943 tons, and was 8% greater than in 1953. Apparent sales of 5,665,687 tons, also the highest on record, were 2¼% greater than during the preceding year. The record export tonnage of about 1.65 million tons, an increase of over 400,000 tons, more than compensated for the ¼-million tons drop in deliveries to the home market, which amounted to about 4 million tons. During 1954 producers' stocks increased by about 200,000 tons to 3,337,086 tons, representing about 9½-months supplies at current rates of domestic consumption. In 1954 this is estimated to have totalled 4.1-4.2 million tons, being accompanied by a moderate reduction of consumers' stocks. Production of sulphur in pyrites from smelter gases is estimated to have totalled 785,000 tons, and total consumption of sulphur in all forms, including sulphur in pyrites imported from Canada, about 5.1 million tons.

Frasch sulphur output in 1954 by the **Jefferson Lake Sulphur Company,** the third largest producer of sulphur in the world, amounted to 433,500 tons, 15½% more than in 1953. This, the highest annual output in the company's history, was accompanied by peak sales and profits. The company's new plant at Manderson, Wyoming, for recovery of sulphur from H_2S extracted from natural sour gas, is believed to have started operations in February of this year to yield 130 tons sulphur per day, about two-thirds of which are earmarked for use at the company's triple superphosphate plant at Montpelier, Idaho, for which plans are virtually completed.

The exploratory work by **The Humble Oil & Refining Company** at their off-shore sulphur dome is progressing satisfactorily. The company hope to be in a position before long to assess probable capital and production costs of off-shore sulphur production in the light of their great experience in similar oil and gas operations.

Italy produced 204,000 tons sulphur in 1954, 8½% less than in 1953. Domestic consumption totalled about 115,000 tons, and, in view of negligible exports, the stockpile rose to 310,000 tons. Early in March, closure of mines and retaliatory strike action were averted by government intervention. A bill, now awaiting passage in Parliament, provides for increased financial assistance in the form of loans to promote modernisation, and a subsidy to permit competitive export sales. Decisive government guidance for the reorganisation of the industry is thought to be necessary to prevent these financial measures becoming another palliative.

The sulphuric acid industry of **Poland,** based on the use of sulphur in anhydrite, pyrites, and smelter gases, is expected to provide 540,000 tons acid in 1954, or about double the pre-war level of production. Further expansion of output, which, it is believed, is planned to reach 800,000 tons per annum by 1960, is to be achieved mainly by the increased use of indigenous anhydrite. A total of three anhydrite acid plants is foreseen, of which one is already in operation. The largest consumer is the fertiliser industry, whose ambitious expansion plans are limited by the availability of acid, for which the growing chemical, metallurgical, and textile industries, are also competing. Although at present elemental sulphur is not used in acid manufacture, the successful development of the recently-discovered ore deposits at Zandomierz may provide a welcome additional source of supply.

The statistical report of the Chemical Products Committee of the **O.E.E.C.** concerning the position of sulphurous raw materials in member countries during the first half 1954 shows that available supplies amounted to 2,434,000 tons sulphur in all forms, which more than met consumption of 2,342,000 tons. Sulphur in pyrites accounted for 58½% of total consumption. Elemental sulphur usage amounted to 483,600 tons, 22½% more than in the preceding half-year, notably as the result of increased use in agriculture, the rayon industry, and sulphuric acid manufacture.

The review of the **wet contact process** developed by Chemiebau Zieren, which permits conversion of sulphur recovered as H_2S from coal gases into sulphuric acid, shows the economic merits of utilising this source of sulphur. The nature of this type of process points to its increasing application in combating air pollution. Plant of Chemiebau Zieren design is manufactured in the United Kingdom by the Power-Gas Corporation of Stockton-on-Tees.

Although the **world price,** in terms of the price level of U.S. sulphur, has remained unchanged, the tone of the market has weakened in recent months, as producers shipping from destinations comparing unfavourably with U.S. Gulf ports were obliged to lower their effective f.o.b. prices in order to maintain relative parity with world prices.

The level of production in the U.S.A., strengthened by the start of operations at the Chacahoula dome, of about 5.9 million tons per annum, is adequate to meet the increased domestic demand, now about 7% greater than six months ago, and enables producers to encourage export orders. Export shipments have started, though mostly of trial cargoes, of Mexican Frasch sulphur, at present being produced at an annual rate of about ½-million tons.

Chilean sulphur exports continue to depend on compensatory commodity imports, and, although competitive, are not finding ready markets. Strong demand for pyrites on the Continent and in the United Kingdom is being adequately met by European producers. Prices remain unchanged, though improved cinder values on the Continent favourably affect the net cost of sulphur to pyrites users.

The immediate **supply position** of sulphur may further ease as the availability of Mexican sulphur presses on the market, which may also be offered competitive, though subsidised, supplies from Italy.

The Sulphur Industry of the United Kingdom

GENERAL

AMONGST the sulphur industries of the world, the United Kingdom occupies fourth place, preceded only by the U.S.A., U.S.S.R., and Japan. Whereas in these countries the industries are almost exclusively based on indigenous raw materials, the United Kingdom has to depend on foreign sources for more than one-half of its sulphur requirements. This dependence, which to-day affects the industry to a lesser degree than ever before throughout its two-centuries-old history, has determined its pattern, growth, and location under the influence of changes in the type or source of raw materials supply. In the last quarter-century, the most potent factor has undoubtedly been the development of native anhydrite supplies, for use in direct manufacture of ammonia sulphate and as raw material for sulphuric acid manufacture. By the autumn of this year, when the last of three new plants starts operations, anhydrite will provide about 32% of the country's total sulphur usage, with anhydrite acid production accounting for 19% of total output. The last-named development will complete the 1951 programme of conversion and new construction. Inaugurated at a critical period when the post-war expansion of the acid industry, based on the use of elemental sulphur, was halted by a world-wide shortage, this programme aimed at reducing the industry's dependence on imported elemental sulphur. The statutory limitations imposed on its use, and the cut by about one-eighth in the available brimstone burning capacity were to be compensated by the fourfold increase in plant capacity for anhydrite acid, a one-third increase of that for spent oxide, and a threefold increase of that for imported pyrites. Production at the new projects first showed its effect in 1954.

Sulphur consumption in all forms then totalled 1,051,000 tons, the highest on record, of which about 19% was used as anhydrite for direct manufacture of ammonium sulphate, 11% in elemental form for industrial (" regular ") purposes, and 70% in sulphuric acid manufacturing. Indigenous resources in the form of sulphur in anhydrite, spent oxide, zinc smelter gases and recovered from oil refinery gases accounted for 46% of total usage, while imports of sulphur in pyrites provided 22½%, and those of elemental sulphur 31½% of total requirements. Total elemental sulphur consumption, of which about 11% was supplied from domestic sources, amounted to about 373,000 tons.

The expanding level of industrial activity in the United Kingdom and the emphasis on greater agricultural output point to further increases in sulphur consumption, especially by the viscose rayon and sulphuric acid industries. Apart from the increase in anhydrite supplies for direct manufacture of ammonium sulphate, governed by domestic and export demand for this fertiliser, no major expansion of sulphur supplies from domestic sources may be expected in the immediate future. In the longer term, the industry is looking to the wider application of recovery of sulphur from oil and coal gases, which, in view of the growing political pressure to abate air pollution, may no longer be circumscribed by strictly economic considerations.

PRODUCTION

The only native sulphurous raw material occurring in the United Kingdom is anhydrite. Deposits of sulphur ores are wholly lacking, and there are to-day no occurrences of pyrites that are capable of being economically worked on a large scale. Most would

involve deep mining and concentration of low grade sulphide ores. In the absence of these conventional sources of sulphur supply, the contributions made by recovery of sulphur from coal and petroleum gases are of great and increasing importance. Perhaps the most economic source of sulphur supply, although limited by the extent of the metallurgical operations, is that contained in the flue gases of the country's two principal zinc smelters which, based on imported zinc blende, permit the production of sulphuric acid.

Production of sulphur in all forms in the United Kingdom is estimated to amount to about 480,000 tons per annum, and by the end of 1955 is expected to rise to an annual rate of 600,000 tons, mainly as the result of increased anhydrite mining operations to feed the three new acid plants scheduled to start during the year.

The distribution of the various sources of supply is estimated as follows :—

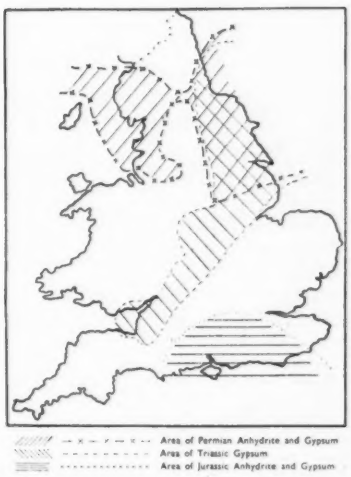


Fig. 1

	End 1954	*End 1955*
	%	%
Sulphur in anhydrite for direct sulphate of ammonia manufacture	42	35
Sulphur in anhydrite for sulphuric acid	8	24½
Sulphur recovered from coal gases	31	24½
Sulphur recovered from petroleum refining gases	6	6½
Sulphur in pyrites	½	½
Sulphur in zinc smelter gases	12½	9

Anhydrite

Deposits of calcium sulphate in the form of gypsum or anhydrite are substantial and widespread. The three principal deposits, as shown in the map, represent estimated reserves of 182 million tons anhydrite (containing theoretically 23.5% sulphur) and 100 million tons gypsum (18.7% sulphur), although further exploration is likely to disclose vast additional tonnages.

Owing to the thinness and irregularity of seams of the triassic gypsum deposits, these are unsuitable for large-scale production. Exploitation has until recently been confined to Imperial Chemical Industries' Billingham mine, supplemented by a small output from the Cocklakes mine of the British Plaster Board Limited, near Carlisle. The capacity of the Billingham mine has recently been increased by 127,000 tons per annum to meet the needs of the new acid plant, raising its total capacity to over 1¼ million tons per annum anhydrite, providing under almost ideal conditions the high-grade homogeneous material required for ammonium sulphate and sulphuric acid production. The increased anhydrite requirements of the new sulphuric acid plants are being met as follows: British Plaster Board (Holdings) have developed their Long Meg (Cumberland) mine to produce 240,000 tons per annum to supply United Sulphuric Acid Corporation (Widnes), and Solway Chemicals Limited have opened up a mine on the West Cumberland coast near their new works. This mine is designed to produce 7,000 tons anhydrite per forty-hour week, and

consists of two drifts driven into the massive deposits under St. Bees Head.

To sum up, by the end of 1955, anhydrite mining capacity in the United Kingdom will amount to 1.8 million tons per annum, representing a recoverable sulphur content of about 380,000 tons.

Pyrites

These occur widely distributed and in small deposits either in veins associated with other sulphide minerals, or in sedimentary deposits, usually clays, shales, and occasionally sands. In the latter half of the nineteenth century, vein deposits in Wales, Devon, Cornwall, Derbyshire, Lancashire, and Scotland, associated with metallic sulphides (lead, tin, and copper), yielded over one-quarter million tons pyrites. Small tonnages of pyrites were produced from sedimentary deposits in Kent, and disseminated deposits in shales occur in the Scottish Highlands.

In recent years, production of pyrites has been confined to that recovered in coal-washing plants. During the 1914-18 war and during the inter-war years, production was confined to hand-picked lump pyrites at a rate of about 10,000 tons per annum, declining to about 4,000-5,000 tons per annum. During the period 1940-45 output rose to 9,000 tons per annum of ore containing 38-42% sulphur and 10-12% carbon, about one-half being used by copper smelters and for other metallurgical purposes. To augment these supplies, the recovery of coal pyrites fines was undertaken at a number of selected collieries by use of wet and dry separation methods. Pyrites recovery of up to 80% was achieved, yielding products containing 42% sulphur and 4-5% carbon, at prices related to imported ores. A total of about 70,000 tons was so produced. Since the war, output of coal pyrites has steadily declined and at present amounts to about 5,000 tons per annum fines and 3,000 tons per annum lump pyrites. Investigation into the recovery of pyrites from pulverised coal by air elutriation or fluidised bed techniques have not given promise of becoming economical, and it is not thought that there is any prospect of increased quantities of pyrites becoming available from coal cleaning. Similarly there is no prospect of production of pyrites from sulphide ore deposits, since the cost would be prohibitive even by comparison with imported pyrites, already an expensive source of sulphur.

Recovery from Coal Gas

British coal as mined contains up to 4% sulphur in various forms, with an average of about 1.5% which, at current rates of domestic consumption, represents over three million tons per annum sulphur. Of these, only about 140,000-150,000 tons are recovered annually, almost exclusively in the form of spent oxide containing 42-50% sulphur, which results from dry purification of town gas supplies. This form of sulphur recovery is undertaken only to conform with the law, which prohibits the sulphur contamination of town gas (maximum H_2S content 1.5 parts per million). In view of its simplicity and high standard of reliability, dry purification using ferric oxide boxes is still considered by the industry to be the most attractive method, although it is not in itself economical. Research and development is progressing into mechanical handling, use of fluidised iron oxide, and improved purification materials, with a view to reducing costs by greater efficiency.

In the year ending 30th June, 1954, a total of 271,000 tons spent oxide was produced in the United Kingdom. The high grade material is reserved for the use of the domestic sulphuric acid industry, while the lower grade is available for export. In the past two years, output has approximately equalled domestic consumption at a level of about 280,000 tons. Exports of about 40,000 tons per annum have caused a reduction in spent oxide stocks from nearly 250,000 tons in 1952 to 141,000 tons in 1954.

The removal of sulphur, usually in the form of H_2S, from carbonisation

gases, has been the subject of extensive research, resulting in the development of a wide range of wet processes, based on oxidation or equilibrium methods, which permit the utilisation of the recovered H_2S either in the form of sulphuric acid or elemental sulphur.

Whereas their application for town gas purification has not so far been deemed economically viable, the installation in 1952 of a Collin desulphurising plant at the Corby coke ovens of Messrs. Stewarts and Lloyds, Limited, may be a pointer to the extension of gas cleaning in this section of the industry. Similarly, the proposed washing of flue gases at power stations with a solution of ammonia, resulting in by-product ammonium sulphate, may further increase this field of sulphur recovery.

The availability of spent oxide is being used by Messrs. Hardman & Holden of Manchester to recover elemental sulphur by a solvent extraction method using carbon disulphide. In recent years, output has fluctuated between 5,000 and 9,000 tons per annum, being about 9,000 tons in 1954.

Recovery from Oil Refinery Gases

Of the oil refineries in the United Kingdom, the following have facilities to recover sulphur* :

	Capacity refined sulphur
Shell Petroleum Company, Ltd.—Stanlow	15,000 tons per annum
Esso Petroleum Company, Ltd.—Fawley	14,000 tons per annum
British Petroleum Company, Ltd.—Grangemouth	6,000 tons per annum

In 1954, sulphur production from this source is believed to have totalled about 30,000 tons, excluding the sulphur equivalent of sulphuric acid produced from hydrogen sulphide arising in the desulphurisation plant at Stanlow. The potential of this plant is 33,000 tons (100% H_2SO_4).

Sulphur in Zinc Smelter Gases

The smelting operations of the Imperial Smelting Corporation at Avonmouth and Swansea result in the arising of about 60,000 tons per annum sulphur in the form of sulphur dioxide contained in flue gases. This is recovered in full as by-product sulphuric acid. The Avonmouth Works include an auxiliary exit-gas cleaning plant (described in *Bulletin No. 5*), which reduces sulphur losses to the atmosphere to negligible proportions.

CONSUMPTION

In the record of expansion of the sulphur using industries of the United Kingdom, the year 1954 was an important landmark, since, for the first time, consumption of sulphur in all forms exceeded one million tons per annum. Comparative data are as follows :—

	1950	*1951*	*1952*	*1953*	*1954*
	000's tons				
Anhydrite for direct manufacture of ammonium sulphate ...	180	170	193	201	206
Sulphuric acid manufacture	638	571	533	662	730
Other industries (" regular ")	112	95	79	95	115
	930	836	805	958	1051

The general pattern of the country's raw materials supply is of necessity governed by the needs of the sulphuric acid industry. The impact of the conversion and construction programme initiated by the industry in 1951, which was aimed at reducing the use of imported brimstone mostly by the provision of new sulphuric acid plants based on imported pyrites, indigenous spent oxide and anhydrite, is already felt, and by the end of this year its full effect will be apparent. This pattern has undergone significant changes, mainly in the light of the availability and relative cost of imported raw

*Various aspects of sulphur recovery from oil in the United Kingdom were the subject articles in Bulletin Nos. 4 and 6, pages 35 and 48-50 respectively.

materials, and the increasing use of indigenous anhydrite and of by-product or recovered sulphur.

	1928	1938	1950	1953	1954	1955 (estimated)
	%	%	%	%	%	%
Indigenous raw materials* ...	32¼	42½	40½	47½	46	49
Imported brimstone	25¼	26½	49½	33½	31½	26
Imported pyrites	42	31	10	19	22½	25
Total sulphur	356	493	930	958	1051	1130

Andydrite Sulphur for Ammonium Suphate

The production of ammonium sulphate by the interaction of synthetic ammonia and anhydrite was developed by Imperial Chemical Industries at Billingham in the late twenties. The contribution of this source to the total United Kingdom production of this important fertiliser has progressively increased until at present it accounts for about 70%.

Elemental Sulphur for " Regular " Uses

Amongst the wide range of industrial users of elemental sulphur in the United Kingdom the viscose rayon industry is the most important.

It accounts for about 60% of current sulphur demand, and thus, as shown in the graph below, its CS_2 requirement is the main factor determining the level of regular sulphur consumption. Messrs. Courtaulds, Limited, account for the entire United Kingdom output of viscose rayon filament and staple fibre, which in 1954 amounted to 219.7 and 228.1 million lb. respectively. The production of SO_2 and sulphites, which represents about 10% of total " regular " sulphur usage, is effected by a number of chemical manufacturers. As the bulk of the country's wood pulp requirements are imported, sulphur usage by this industry is small, amounting to about 2,000 tons per annum. The requirements of the rubber industry for compounding rose to about 11,000 tons† in 1954, having in recent years shown a downward tendency, mainly due to contraction in output, but also as the result of hard rubber accounting for a smaller proportion of total production.

By 1954, the production of refined and ground sulphur for agriculture—including insecticides and fumigants—recovered from the setback caused by the earlier sulphur shortage. . The present level of activity reflects greater domestic demand as well as expanding exports. The principal producers of ground sulphur in the United Kingdom are Messrs. F. W. Berk & Company, Limited, of London ; Alfred Smith & Company, Limited, of Hull ; Cowburn & Cowpar, Limited, of Manchester ; and Union Alkali Company, Limited, of Manchester.

The consumption of sulphur in the manufacture of dyes and ultra-marine represents another important outlet, and this, as well as the large number of miscellaneous uses, tends to be governed by the general level of industrial activity.

The following graph shows details of consumption for the period 1950-1954 :—

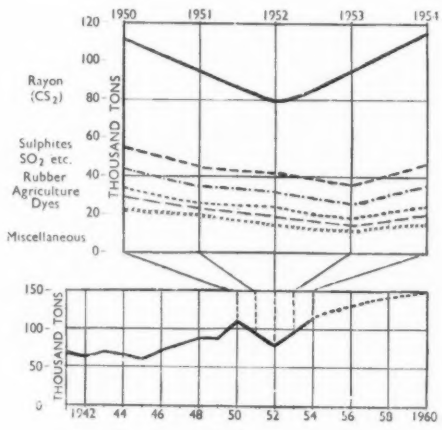


Fig. 2

*Sulphur in anhydrite, spent oxide, zinc smelter gases, and recovered from oil refinery gases.

†This tonnage represents requisitions, whereas actual consumption is believed to have totalled about 8,000 tons—8% more than in 1953.

Prior to 1952, the bulk of requirements of regular sulphur were imported almost exclusively in the form of bright U.S. Frasch sulphur. The introduction of recovery facilities at oil refineries permitted the production of very pure sulphur, which for processes such as rubber compounding and the manufacture of chemicals showed many advantages. At present, about 23% of regular sulphur requirements are met from this source, which, together with sulphur recovered from spent oxide, raises the proportion of indigenous supply to 31%. In 1954, total consumption amounted to 115,000 tons, the highest on record, or 21% greater than during the preceding year. It represents 30.7% of total elemental sulphur consumption in the United Kingdom.

Regular sulphur requirements in the immediate future, governed primarily by the level of activities in the viscose rayon industry, may be expected to rise steeply. Messrs. Courtaulds Limited have announced plans to erect a new plant at Grimsby with a capacity of 100 million lb. staple fibre, representing a 50% increase of existing facilities or a 26% increase of total viscose rayon capacity. The expansion of requirements of other industries using regular sulphur is indeterminate, though it is probable that this may be at the rate of 3-4% per annum. Of the various uses, production of refined and ground sulphur for agricultural purposes at home and for export promises to show the greatest relative expansion. It is estimated that "regular" sulphur consumption in 1955 may rise to 125,000 tons, to reach 140,000 tons by 1958.

Sulphuric Acid*

Production

In 1954, output of sulphuric acid amounted to 2,042,500 tons (100% H_2SO_4), the highest on record and 9% greater than in 1953, the previous peak-year. The following graph shows acid production for the period 1945 to 1956: —

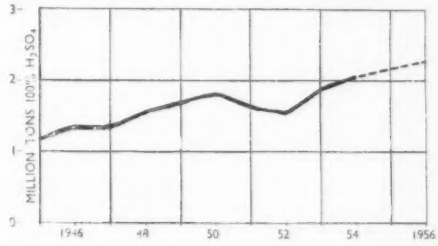


Fig. 3

The changes in the proportions of sulphuric acid produced from the various raw materials at the disposal of the industry are indicated below. The figures reflect the increase of acid supplies from plants based on the use of pyrites, spent oxide and anhydrite, and the reduction of elemental sulphur use in acid manufacture. The estimates for 1955 and 1956 indicate the position that may result if no change were to take place in present Government policy of restricting the use of elemental sulphur in acid manufacture to that required to produce the balance between requirements and the full employment of acid capacity based on other raw materials. It was reported in the summer of 1954 that the National Sulphuric Acid Association were contemplating making representations to the Government, and it is thought that the

From	*1920*	*1928*	*1938*	*1950*	*1953*	*1954*	*1955 (Estimated)*	*1956*
	%	%	%	%	%	%	%	%
Elemental sulphur ...	†	20.1	21.3	57.2	39.1	36.2	27.5	23.4
Sulphur in pyrites ...	82	45.0	40.4	14.8	26.8	31.8	34.9	33.7
Sulphur in spent oxide	17	25.6	20.3	14.5	20.9	18.9	17.9	18.1
Sulphur in zinc contrates	†	9.3	11.6	8.0	7.7	8.0	7.3	7.1
Sulphur in anhydrite ...			6.4	5.5	5.5	5.1	12.4	17.7
Total acid (000's tons)	1053	928	994	1803	1875	2042	2180	2260

†Less than 1%.

*We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

restrictions on "acid" sulphur usage may be lifted by the end of this year.

Prior to 1950, the majority of sulphuric acid plants were based on the use of a single raw material, and alternative facilities, if available, were designed to supplement the concentration or quantity of SO_2 gases rather than to give to the acid maker free choice of the more economic of two raw materials. An important feature of the 1951 programme of conversion and new construction was the introduction of a greater measure of flexibility by the addition, at a number of established acid plants, of new pyrites roasting or spent oxide burning furnaces designed to serve sulphuric acid installations formerly based on elemental sulphur. In most instances the sulphur kilns were retained, and it is estimated that only about 10-15% of brimstone burning capacity then available was actually eliminated. The main object of the programme was to increase the acid making capacity of the country and this was achieved partly by the replacement of lead chambers by tower-units or the installation of larger contact acid units, but chiefly by the construction of a substantial number of new complete installations based on raw materials other than brimstone.

Effective acid production based on available consumption capacity of the various sulphurous raw materials is as follows :—

	1950	*1953*	*1954*	*Estimated position on*	
	(000's tons H_2SO_4)			*1.1.55*	*1.1.56*
Effective production capacity ...	1980.5	2266.8	2366.8	2450	2700
Employment	91%	82.7%	86.4%	84%	81%
Chamber acid capacity	796.7	794.1	790.4	790	790
Contact acid capacity	1183.8	1472.7	1572.4	1660	1910

In practice the total capacity is less than the aggregate of the above as at several plants there is provision to use alternative raw materials.

Effective production capacity, employment and the relative extent of chamber and contact acid facilities show the following changes :—

It is estimated that in 1954 acid plants based on zinc smelter gases operated in excess of rated capacity, those based on anhydrite at near capacity, pyrites acid plants at about 90%, spent oxide acid plants at about 88%, and brimstone acid plants at about 76%. The impact over the whole of 1955 of acid supplies from new pyrites roasters and over part of the year, from the new anhydrite plants* is expected to result in a further reduction to about 65% in the employment of brimstone burning capacity.

The majority of the new pyrites acid plants incorporate flash roasting furnaces which were previously not employed in this country. This practice favours raw material supplies in the form of pyrites concentrates, since in the case of crude ore, such as the bulk of supplies from Spain, fine grinding is necessary and not wholly satisfactory. One new plant, that of Messrs. John Riley & Company, of Hapton, incorporates a turbulent layer roaster, of the type developed by Badische Anilin & Soda Fabrik, with an annual capacity of about 30,000 tons

Pyrites roasters ...	800,000 t.p.a. acid (100% H_2SO_4), an increase of 520,000 tons
Spent oxide burners ...	420,000 t.p.a. acid (100% H_2SO_4), an increase of 130,000 tons
Anhydrite burners ...	415,000 t.p.a. acid (100% H_2SO_4), an increase of 310,000 tons
Zinc smelters	150,000 t.p.a. acid (100% H_2SO_4), unchanged
Brimstone burners ...	950,000 t.p.a. acid (100% H_2SO_4), a reduction of 125,000 tons

*For details of these plants please refer to Bulletin No. 7, Page 44.

pyrites, which is suitable for the use of a fairly wide range of grain sizes.

Amongst the new pyrites roasting plants or plant extension developed since 1951 the following might be mentioned:—

Company	*Location*	*Approximate Annual Consumption Capacity tons*
Associated Ethyl Co. Ltd.	Anglesey	10,500
Courtaulds Ltd.	Trafford Park	100,000
British Titan Products Co. Ltd.	Grimsby	50,000
Peter Spence & Sons Ltd.	Widnes	28,000
Laporte Industries Ltd.	Castleford and Stallingborough	50,000
Scottish Agricultural Industries	Sandilands	26,000
Imperial Chemical Industries	Ardeer	40,000
West Norfolk Farmers	Kings Lynn	31,000
Spencer, Chapman & Messel Ltd.	London	36,000
Imperial Smelting Corp. Ltd.	Swansea and Avonmouth	50,000

The principal development of acid plants based on spent oxide has been carried out by Messrs. Lawes Chemical Company at Barking Creek, East Midlands Coal Board at Chesterfield, North Thames Gas Board at Beckton, and South Eastern Gas Board at Greenwich. The two last-named plants also utilise the small quantities of H_2S arising in the course of gas cleaning.

With the exception of the new acid plant built by Shell Petroleum Co. Ltd. at Stanlow, and which is based partly on recovered H_2S and partly on the use of recovered brimstone, no new brimstone acid plants were built in the past four years. The Immingham plant of Messrs. Fisons Ltd. remains the largest unit of the type in the United Kingdom with an annual consumption capacity of about 35,000 tons elemental sulphur.

It is estimated that of the capacity added since 1951, 65-70% is captive; in the case of the old-established plants, the proportion was only about 40%, so that at present captive acid represents about half of total United Kingdom production.

CONSUMPTION

The high rate of industrial activity in the United Kingdom during 1954 is reflected in the highest total acid consumption on record, amounting to 2,047,700 tons (100% H_2SO_4), which is 7¾% greater than that in 1953, the previous peak year.

Over the period 1928-1954, acid consumption has increased at an annual rate of 3.1%, whereas from 1948-1954 the rate of increase amounted to 4.7%, or an aggregate expansion of 31%. This compares with the index of industrial production in the United Kingdom, which, since 1948 (100), advanced 28%. Sulphuric acid consumption, representing 90.6 lb. per head of population in 1954, as against 70 lb. in 1948, is spread over very many industries, of which the following are the most important:—

Fertilisers: About 36½% of total acid usage is taken up by manufacturers of superphosphate and of ammonium sulphate. In spite of the setback in 1954, acid use for the production of phosphatic fertilisers, notably the more concentrated forms, shows an upward trend. In the manufacture of ammonium sulphate, the use of acid is confined to conversion of by-product ammonia and of synthetic ammonia produced at Nitrogen Fertilisers, Limited, Flixborough. Production is expanding, but an increasing proportion of the sulphur requirements may be met by recovery from coal gases at coke oven plants or power stations.

Pigments and Dyes: These account for over 15% of total acid consumption. The spectacular increase in the product of titanium oxide has already resulted in the construction of three new acid plants to

meet the industry's needs, and, in view of its continued growth, its share of total acid usage, which in 1954 amounted to about 10%, is expected to increase further.

Rayon and Transparent Paper: At present over 12% of the total usage is consumed by these industries. The projected new rayon plant, mentioned earlier, is expected to include provision for an integrated acid plant, possibly based on elemental sulphur.

Metallurgy: The high rate of activity in the iron and steel industry is to some extent reflected in the increased acid use. In 1954, it accounted for about 5½% of total consumption, and its share is expected to rise when the new tinplate works in South Wales start operations in 1956.

The graph indicates the changes in acid consumption, and is accompanied by a table showing comparative data for the principal consuming industries :—

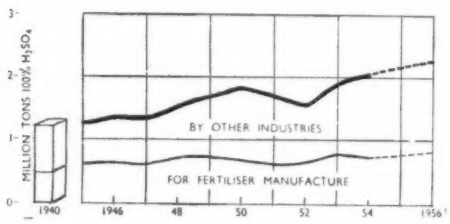


Fig. 4

Major changes in acid consumption, comparing 1954 with the preceding year, were as follows :—

	Tons	*Increase/ Decrease*
Titanium oxide	+42,100	+25 %
Superphosphate	−25,300	− 5 %
Soap, detergents and glycerine	+17,100	+56 %
Rayon and transparent paper	+15,600	+ 6½%
Dyes	+15,600	+23 %
Iron pickling	+12,000	+12½%

Other changes, though quantitatively small, were recorded for drugs and fine chemicals (+70%), bromine (+38%), paper (+38%), plastics (+36½%), lithopone (+31%), and oil refining (− 14½%).

TRADE

Although the increased use of indigenous sulphur supplies has reduced this country's dependence on foreign sources, it still remains necessary to import the bulk of requirements of elemental sulphur and pyrites.§ Sulphur imports since 1939 have been almost exclusively derived from the U.S.A., whereas previously about one-third originated from Sicily. Small supplementary tonnages have been obtained from Norway and Chile and also recently from Trinidad. The start of large-scale Frasch sulphur production in Mexico is likely to provide an alternative source of supply. The pyrites supplies are derived mainly from Spain. Supplies from Cyprus, limited by availability, currently

	1940	*1950*	*1951*	*1952*	*1953*	*1954*
Superphosphate	247	436	359	370	482	457
Ammonium sulphate	224	259	267	279	287	290
Lithopone and titanium oxide ...	49	20†	21†	106	181	227
Rayon and transparent paper	104	229	212	152	233	248
Metallurgy	100	104	95	103	104	116
Dyes	57	87	85	45	68	84
Oil refining	21	60	67	71	64	55
Chemicals*	185	276	263	234	248	280e
Miscellaneous	218	345	307	192	235	291
	1205	1816	1676	1552	1902	2048

†Lithopone only.

e Estimated.

*Including: Benzole; bichromates; borax; chlorsulphonic acid; formic; hydrochloric; hydrofluoric, oxalic, tartaric and citric acids; paper; phenol (synthetic); phosphates (industrial); plastics; sulphates other than ammonium sulphate and excluding rare earths.

§For details, see Statistical Appendix.

amount to about 20% of total imports. Other, though irregular, sources are Canada, Greece, and Portugal.

In 1954, imports of elemental sulphur amounted to 375,877 tons, valued at £13 8s. 0d. per ton. Pyrites imports totalled 600,522 tons, valued at £6 16s. 0d. per ton. As the result of the changes in raw materials consumption in acid manufacture, the import value of the pyrites so consumed in 1954 exceeded that of imported "acid" sulphur for the first time since 1940.

Exports of sulphur in spent oxide to the Continent slightly compensate this country's sulphur import bill, which in 1954 amounted to over £9 million, of which over £5 million was U.S. dollar expenditure. Spent oxide exports in 1954 totalled about 40,000 tons. Other exports of sulphur were in refined and ground form directed mainly to Commonwealth countries. In 1954, these totalled about 1,500 tons. Export prices range from about £24 0s. 0d. per ton for ground sulphur of 200 mesh grain size, to £29 0s. 0d. for 325 mesh and £32 0s. 0d. for sulphur flowers.

Distribution and Prices

For thirteen years prior to 31st December, 1953, trading in imported sulphurous raw materials was vested in the Ministry of Materials, for whom the National Sulphuric Acid Association were acting as purchasing agents. Although the trade then reverted into private hands, individual members entrusted the Association to bulk-purchase all elemental sulphur and most of pyrites supplies. Similarly, shipping and distribution, where applicable, is administered centrally. At present, the cost of sulphur in various raw materials delivered to consumers' works is approximately as follows :—

Elemental sulphur, £13 15s. 0d. per ton ; sulphur in pyrites, £10 10s. 0d.—£14 10s. 0d. per ton ; sulphur in spent oxide, £8 16s. 0d. per ton.

The wide range in the net cost of sulphur in pyrites is due to varying disposal facilities of pyrites residues. Fines residues find a ready outlet to cement works and blast furnaces while the profitable disposal of flotation pyrites residues continue to meet with difficulties. The development of a plant for partial extraction of precious metal and copper values and the possibility of recovering selenium from certain residues are being examined, and if realised would substantially raise the average net cinder return which over the entire United Kingdom pyrites consumption is estimated at about 7s. per ton sulphur so consumed.

CONCLUSION

The predominant problem of the sulphur industry of the United Kingdom remains the procurement of raw materials. This problem is not one of overcoming a shortage of sulphur, but rather of procuring supplies, in one form or another, under economically most favourable conditions, of which price and assurance of continuous availability are thought to be the main considerations. At present the United Kingdom imports 89% of its elemental sulphur requirements and practically all its pyrites needs, and these imports account for over one-half of the total sulphur consumption. The balance is derived from domestic resources in the form of sulphur in anhydrite and recovered from smelter, oil refinery, and coal gases. The use of indigenous anhydrite has been the largest single factor in reducing the country's dependence on imports. Its use as a raw material for sulphuric acid production is, however, circumscribed by the need for large units being sited favourably in relation to the source of raw material and the market for acid and cement clinker. Under such favourable conditions the cost of anhydrite acid, though higher than that produced from elemental sulphur, compares advantageously with acid produced from pyrites. The completion this year of the anhydrite acid plants scheduled

under the conversion programme is thought to represent, for the time being, the limit of expansion in this field.

One of the main factors underlying the conversion programme was to increase pyrites acid production to 40% of the total output, whilst the use of available brimstone burning capacity was to be restricted to provide only the balance (calculated to fall to 15% by 1956) between requirements and acid produced from other raw materials. As a result of plentiful supplies of elemental sulphur being available, the regulations regarding the use of "acid" sulphur have been interpreted liberally. Even so, brimstone acid production dropped to 36.2% of the total in 1954, and is expected to recede further to 27½% in 1955. In the meantime, the increased quantity of acid produced from other, more expensive, raw materials—notably pyrites—has led to a rise of 4-5% in acid prices.

Total acid capacity—including that based on brimstone—exceeds the present level of consumption, and statistically the progressive fuller employment of brimstone acid capacity would be adequate to meet expanding requirements for 3-4 years. The removal of the existing restrictions on the use of acid sulphur, expected by the end of this year, would, however, for economic reasons, be likely to lead to a fuller use of this raw material, with a corresponding reduction of more expensive other materials, notably pyrites. The need for new plant construction cannot be excluded as acid requirements may arise in localities not economically served by available capacity. Under present and anticipated future conditions of supply, it is probable that such plants would be based on elemental sulphur usage.

In view of the complex nature of the sulphur industry in the United Kingdom, it is important that an equitable balance be maintained in the types and sources of raw materials. In addition a high degree of flexibility is desirable in order that advantage may be taken of varying circumstances of supply and production. In these general considerations the supply of sulphur recovered from oil and coal gases plays, as yet, only a small part. The possibility of these sources assuming greater importance must, however, be borne in mind as Government measures in respect of air pollution could much increase the availability of recovered sulphur and thereby further reduce the industry's dependence on foreign sources of supply.

PYRITES AND SULPHURIC ACID IN JAPAN

General

JAPAN, with a production last year of 2,345,000 tons is the largest pyrites producer in the world. The country has reserves of 25-30 million tons, in sulphur content, which alone should be adequate to meet domestic needs for the next twenty-five years. Additional resources, at least equal to and perhaps several times as large as the developed reserves, are believed to exist in unprospected districts in the home islands. Pyrites were first produced in Japan in 1891, and production rose rapidly to an annual rate of 150,000 tons a year which was maintained from 1900-1919. During the next ten years, production rose to ½ million tons, but the main expansion of the industry occurred in the early thirties. By the time Japan entered the second world war output had risen to nearly 2 million tons pyrites annually. At the end of the war production was virtually at a standstill. However, the pressing need for sulphuric acid—largely produced from pyrites—for the fertiliser, textile and metallurgical industries, which are the mainstay of Japan's economy, led to such a rapid recovery of

the pyrites mining industry that in less than ten years pyrites output has exceeded its pre-war level.

Sulphuric acid output which in 1954 amounted to over 3 million tons is based, to a large extent, on old plants and only since 1951 has the output of contact acid exceeded that produced in lead chamber plants. Most of the output is captive and its predominant end-use in fertiliser manufacture accounts for the large proportion of 50° Bé. acid that is being produced.

In view of the extensive use of pyritic ores and sulphide concentrates in non-ferrous metal production, the use of sulphur in smelter gases for by-product sulphuric acid manufacture has long been a feature of the Japanese industry. In recent years by-product acid capacity has been expanded to about ½ million tons, the third largest in the world, exceeded only by that of the U.S.A. and U.S.S.R., although in spite of increased metallurgical activities, only about 65% is at present utilised. Sulphur so consumed accounts for about 8% of total usage in acid manufacture and the balance is consumed almost exclusively in the form of pyrites.

As Japan has native sulphur reserves at least equal to those in pyritic form, the preferential development of the latter for use by the acid industry appears, at first sight, anomalous. In the past this has been due to the low production cost of sulphur in pyrites which, in view of the comparable occurrence and exploitation of sulphur and pyrites ore deposits, was equivalent to only a fraction of the final cost of refined sulphur. Although the increased application of pyritic ore beneficiation has proportionately raised costs, the general rise in all production costs, since the war, has made a greater impact on sulphur ore refining due to the prevalent wasteful methods and has consequently widened the margin in favour of pyrites. It is questionable whether large scale modernisation and expansion of the sulphur industry, involving heavy capital expenditure, could swing the economic balance the other way. The pyrites industry is conscious of its shortcomings which, the largest producers apart, are manifested by lack of mechanisation and primitive ore dressing methods. Although the government has shown interest in the problems of the industry, no active support has been given, and improvements depend on its own financial resources.

Fig. 5

Pyrites Deposits

Pyrites are found throughout the Japanese islands, but the most important deposits occur in Shikoku and in northern Honshu. The origin and types of deposit vary considerably. Ores with high sulphur content (up to 49%) and low metal values are used for sulphuric acid manufacture only, and an increasing proportion of residues, after sintering, provide feed for the blast

furnaces in the iron making industry. Ores with high sulphur and high metal values are either roasted first for their sulphur content and are then smelted, or they may be used directly as raw material by the metal smelter, in which case the sulphur content would be recovered in the form of by-product sulphuric acid. Pyritic ores with a low sulphur and high metal content are normally supplied direct to metal smelters and the sulphur is not as a rule recovered, although the increasing application of ore beneficiation has increased the scope and consumption of this type of ore in recent years.

Pyrites deposits can be classified under three main types:

1) Deposits consisting mainly of iron pyrite. These include :
   a) Black ore, a replacement deposit usually combined with lead, zinc and yellow copper. The Hanaoka mine is among the largest concerns working this type of deposit.
   b) Pyrite massive replacement deposits with some copper and pyrrhotite. The Yanahara and Kawayama mines are representative.
   c) Bedded deposits of cupriferous pyrite, which includes yellow copper ores of a very low grade. The mines working these deposits are the Besshi, Niii, Sazare, Iimori, Minenosawa, Kune, Hitachi, Suwa and other smaller mines.
   d) Fissure filling deposits worked by the Hosokura and Osarizawa mines.
2) Pyrite deposits associated with sulphur deposit. These consist of either low grade ores mined by the Matsuo and Horobetsu Companies, or massive pyrite found in caves or between

View of the Matsuo Mines. The ore body is penetrated by many layers of underground drifts & tunnels dug out during the Company's 39 years of operation. These passages extend for over 100 miles.

fissures. The latter are represented by the Zao mine.

3) Deposits which mainly consist of pyrrhotite. These include :
   a) Massive replacement deposits in ultrabasic rocks. A number of small mines work these deposits which frequently yield nickel bearing ores.
   b) Contact deposits, combined with pyrrhotite and other kinds of sulphides.

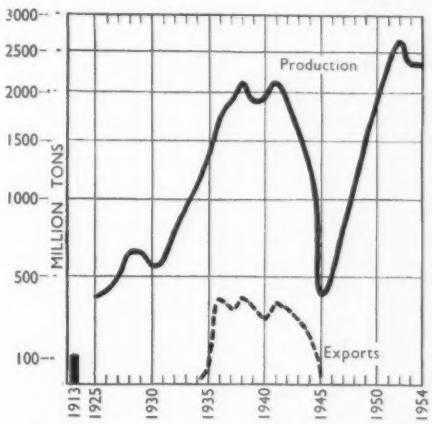
Pyrite is mined by widely varying underground methods. Hand labour is exclusively used in small mines and is still prevalent in large mines, though the latter are introducing mechanisation on an increasing scale. Many types of stoping are employed. Overhand stoping backfill, room and pillar, and shrinkage stoping are the most common. In a few mines square-set stoping is used for remining areas previously worked by overhand stoping with backfill. In several mines of the black ore type, in which the ore is massive, soft and friable, a modified form of caving is employed. Milling methods are very simple, consisting of crushing, sizing and hand-picking. In mines producing metallic ores gravity flotation by separation tables is employed ; in the larger metal mines, modern gravity and flotation plants are used to separate pyrite and metal concentrates.

Pyrites Production

Most of the output comes from 33 major mines, of which two, Matsuo Co., Ltd., and Dowa Mining Co., Ltd., produce about one-half of the national total. Another 20% has been supplied by two other mines, Besshi and Hitachi. The remainder of production is divided approximately as follows : 6 mines, 15% ; 25 mines, 10% ; all others, 5%. About 60% of the national output from 1925-1945 came from mines worked mainly for pyrite, and from sulphur-pyrite mines. The other 40% came from metal mines, chiefly copper, although lead-zinc and gold mines contributed relatively small amounts of by-product pyrite.

The largest producers, and their respective outputs for 1953, are shown below :

	Tons
Dowa Mining Co., Ltd.	611,069
Matsuo Mining Co., Ltd.	466,619
Nippon Mining Co., Ltd.	357,185
Sumitomo Metal Mining Co., Ltd. ...	160,675
Mitsubishi Metal Mining Co., Ltd....	144,325
Mitsui Metal Mining Co., Ltd., ...	70,133
Furukawa Mining Co., Ltd.	64,297



Erratum : In Fig. 6 above for "Million Tons" please read "Thousand Tons."

Production in 1954 was 2,345,000 tons, containing average 41% sulphur. The decline from the 1952 figure is believed to be temporary, and production this year is expected to be about 2½ million tons.

Consumption and Trade

Up to 1934, domestic production of pyrites was wholly taken up by the home market. Subsequently, up to 1945, Japanese output also provided the requirements of Japanese sulphuric acid plants in Korea and Manchuria, and exports during the peak years (1936-1942) averaged 350,000 tons annually. Imports were small and sporadic, chiefly from Canada and Formosa. From 1925-1945 these totalled 306,930, and during the period of rapidly increasing consumption after the war, particularly 1951-1952, which was not then matched by production, more than 100,000 tons of pyrites were imported. The following graph shows consumption of pyrites from 1948-1953 :

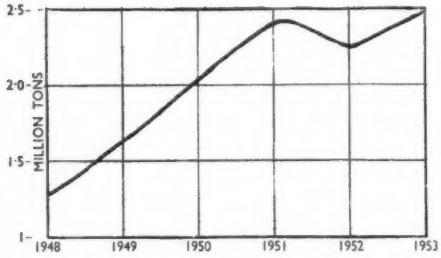


Fig. 7

Sulphuric Acid

The raw materials used for sulphuric acid in Japan are pyrites, pyrrhotite, sulphur in smelter gases, low grade sulphur fines and, to a very limited extent, elemental sulphur and spent oxide. The modern sulphuric acid industry dates from 1891, when pyrites were first used as a raw material. As shown in the table below, it is to-day the predominant source of sulphur in this industry.

The use of sulphur in smelter gases in by-product sulphuric acid manufacture, which was started at the Miike Refinery in 1916, is assuming increasing importance, notably in connection with copper smelting operations. It is thought that this may be partly due to higher grade concentrates becoming available.

Consumption of the various raw materials is currently as follows :

	1953	*Tons*	*1954**
Sulphur ores	2,178,403		2,378,000
Imported pyrites	7,091		7,100
Zinc blende and lead ores	162,345		175,000
Cupriferous pyrites	62,181		69,000
Copper concentrates	58,866		61,000
Spent oxide	2,188		10,000
Elemental sulphur	1,999		
Total sulphur content ...	997,000		1,088,000

Details of sulphuric acid production for the period 1925-1954 are shown in the graph at the head of column two.

The following table shows details of acid output from the various raw materials used :

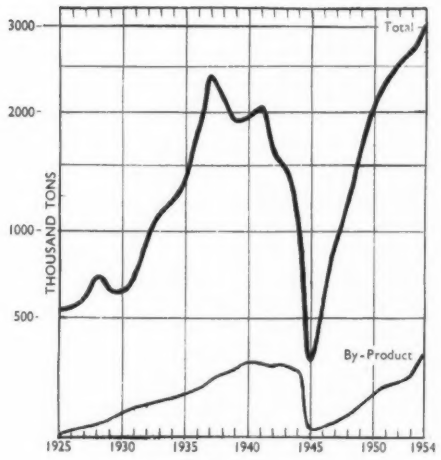


Fig. 8

Tons 100% H_2SO_4		
Acid produced from :—	*1953*	*1954**
Sulphur ores†	2,454,707	2,690,000
Copper ores‡	89,987	184,000
Zinc blende and lead ores	139,002	145,000
Total	2,683,696	3,019,000

The rapid expansion of acid production in the 1930's coincided with the increasing application of the contact process, and it was estimated that in the early war years 40% of output was contact acid and 60% was produced in tower and chamber acid plants. In 1954, the tonnage of contact acid represented about 56% of total output. It is significant that the proportion of contact acid produced from copper ores was only about 32% whereas that produced from zinc blende was 75%. Contact acid production based on other raw materials amounted to nearly 57%.

*Annual rate based on data for January-September, 1954.
†Including iron pyrites (domestic and imported), pyrite and sulphur ore mixtures, elemental sulphur, and spent oxide.
‡Including copper concentrates and cupriferous pyrites.
In addition to the above primary production, about 26,000 tons recovered acid were available in 1954.

The plant capacity of the six leading sulphuric acid producers is shown below :

Producer	Producing capacity (thousand tons 100% H_2SO_4) Contact process	Nitration Process	Total
Nissan Chemical Industry Co., Ltd. ...	199	1,060	1,260
Nitto Chemical Industry Co., Ltd. ...	205	376	581
Toyo-Koatsu Industries Inc.	465	—	466
Sumitomo Chemical Co., Ltd.	395	31	425
Showa Electrochemical Industry Co., Ltd.	124	292	416
Ube-Kosan Industries, Ltd.	182	199	381
Total	1,570	1,958	3,529

Sulphuric Acid Consumption

The fertiliser industry is the largest consumer of sulphuric acid, predominantly for the manufacture of ammonium sulphate. The rapid growth during the last five years of the textile industry, notably rayon, has more than trebled acid use in this branch of the industry, which is expected to use nearly 400,000 tons 100% H_2SO_4 in 1955. The following table shows the consumption of sulphuric acid in the various industries, from 1949 to 1954 :

Industry	000's tons H_2SO_4 1949	1950	1951	1952	1953	1954
Nitrogen fertiliser	880	1,124	1,224	1,410	1,475	1,572
Phosphate fertiliser	447	512	561	520	590	674
Inorganic chemicals	52	68	79	82	94	108
Textiles	79	141	202	201	262	306
Dyes, etc.	36	45	66	61	75	86
Electrolytic refining at mines	12	14	15	13	14	15
Iron and steel	18	34	40	38	43	52
Metal industries	12	16	21	24	28	34
Petroleum	9	19	37	30	41	42
Others	67	71	133	107	153	171
Total	1,612	2,044	2,378	2,486	2,775	3,060

Conclusion

In the absence of an export market, only the level of the domestic economy determines the development of the Japanese pyrites industry, and recent trends indicate that in the immediate future output may rise up to 5% per annum to meet the demand.

The two principal factors influencing sulphuric acid consumption are food and exports. Manufacture of fertiliser to-day accounts for over 73% of total acid usage, and Japan's principal export industries take up 20% ; they are textiles (10%), metallurgical industries (3½%) and heavy chemicals and dyes (6½%). Although the Japanese population problem necessitates the maximum use of fertilisers, which will in itself result in a constant increase of acid consumption, it is probable that in view of the expanding industrial activity in Japan, caused by the country's essential need to export, the proportion of acid so used may increase in relation to that used in the fertiliser industry. One of the effects of these developments will undoubtedly be increased emphasis on acid production at the lowest possible cost as in an economy based on relatively cheap labour, such as Japan, the cost element represented by raw materials assumes correspondingly greater importance. The present pattern of raw material consumption in acid manufacture meets these requirements and there are no valid reasons to expect a change for some time to come.

The predominance of pyrites does, nevertheless, depend on the industry's ability to achieve increased output economically, and this points to further concentration of production in large, modernly equipped units and progressive elimination of the primitive small mines. Failing this, elemental sulphur produced at world price levels, which Japanese ore refiners hope to achieve before long by installation of modern plant, is bound to claim its share of the market.

Prices and Trends

Prices

THE upward movement of sea freights was checked in recent weeks, and charters based on current rates show a 4-6% reduction in the delivered cost of sulphur compared with the peak rates of late January. F.o.b. prices of sulphur from destinations comparing unfavourably with U.S. Gulf ports have receded, in some cases heavily, in order to maintain relative parity with world prices, as expressed in the quotations of the U.S. sulphur producers. Both for domestic and export shipments, these have remained stable, nor has there been a change in price differentials between bright and off-colour grades.

Mexican producers who effected a number of sales in the past three months were obliged to reduce their effective price well below that of corresponding U.S. grades as the freight differential for a time put them at a heavy disadvantage. Sales are reported at an f.o.b. equivalent of $27.50-$28.00, and recently as low as $26.50. The latter figure, though believed to be exceptional, does point to the producers' determination, or perhaps even their need, to secure markets for their growing output.

The price of Chilean sulphur, which, in view of exports being limited by compensating commodity imports, reflects neither production costs nor the official Chilean export price of about U.S. $32, remained under heavy pressure. The sharp rise in freights, which at one time reached 120/-, occasioned f.o.b. equivalents as low as U.S. $19 per metric ton sulphur to permit delivered costs at parity or slightly below U.S. sulphur shipments. The sales in question are believed to have totalled 5,000-7,000 tons to Western Germany and smaller shipments to France.

Export sales of Japanese sulphur are reported to have been made to Australia at levels comparable with delivered prices of U.S. sulphur. The corresponding f.o.b. price is, however, believed to be well below average production costs of Japanese sulphur. Italian sulphur prices are unchanged at about L.44,000 (£25½) per metric ton f.o.b. Impending legislation (see page 28) includes provision for the payment of a subsidy to offset losses on sales which are intended to be made at world price levels.

The following table shows a comparison of prices of sulphur of different origin. F.o.b. prices and freights are based on recent quotations.

	f.o.b. Country of origin	*Freight‡ to U.K.*	*c.i.f. U.K.*
U.S.A.	U.S. $29.50 — $33	72/6	£14⅛ — £15½
Mexico	U.S. $29.50†	80/-	£13⅞ — £14⅛
Italy/Sicily ...	L.44,000	60/-	£28½
Chile	U.S. $23	100/- / 125/-	£13¼ — £14½
Japan	U.S. $34*	100/-	£17⅛
Ecuador ...	U.S. $42	95/-	£19½
Canada	$20 ex works	100/-	£19⅜

The competitive nature of the present world sulphur market has been emphasised by several top executives of the U.S. sulphur industry.

Although prices are expected to be weak as the result of Mexican producers' anxiety to market as large a proportion of their output as possible, it is thought unlikely that U.S. producers will lower their present price level. As expressed in earlier reviews of price trends, a significant change may occur about the middle of this year, but only if the producers' relative marketing positions were serious enough to warrant it. So far there are no conclusive signs of this happening.

†Less freight adjustment to achieve parity with U.S. Gulf freights.
‡Based on bulk cargoes of 5,000-6,000 tons on the usual sulphur terms of chartering.
*Calculated on basis of sales to Australia.

Users of sulphur in pyrites were even more adversely affected by the high level of sea freights and the delivered cost of sulphur in pyrites is estimated to have risen by up to 30%. As previously reported, the level of European pyrites prices f.o.b. has remained unchanged at about £4 15s. 0d.-£5 5s. 0d. per metric ton. Net sulphur costs to pyrites consumers on the Continent are likely to decrease, as apart from the rise in sea freights having been checked, cinder values are expected to appreciate further in view of the continued high level of non-ferrous metal prices and improved iron ore prices.

Supply

Production in the U.S.A. of Frasch and recovered sulphur continued at a high level during the first quarter of the year, and productive capacity was increased by about 200,000 tons per annum when Chacahoula dome of Freeport Sulphur Company started operations in the early part of March. The high level of industrial activity which, according to the seasonally adjusted index, had advanced 10 points since last August to 133 *(1947/9 = 100)*, has resulted in strong sulphur demand, but this is being met comfortably. Under continuing sales pressure export deliveries by U.S. producers are being maintained, in the face of strong Mexican competition.

Mexican production is currently believed to be at a daily rate of 1,500-1,600 tons sulphur. Both producers, Mexican Gulf Sulphur Company and Pan American Sulphur Company, completed their shipping facilities at Puerto Mexico early in the year, and have progressively built up sizeable stockpiles at mine and port. First export shipments were effected in early March, and sales are reported to have been made to many destinations, including United Kingdom, W. Germany, France, Sweden, South Africa and India, although the quantities involved indicate that they represented little more than trial cargoes or the supply of consumers' new requirements. Qualitatively, the present output of Mexican sulphur compares with average U.S. off-colour grades, and is likely to have similar burning characteristics.

Italy's sulphur output continues to exceed domestic requirements and, whilst remaining uncompetitive, the export surplus is being added to the stockpile which is estimated to have grown to about 320,000 tons.

Chilean production remains unchanged at a rate of about 30,000 tons per annum. Due to the low level of exports in 1954* to Chile's traditional customers, Brazil and Argentina, there is some uneasiness amongst sulphur producers who are now wholly dependent on intermittent commodity transactions giving the National Institute of Commerce the opportunity to call for export supplies.

Production of sulphur in Japan remains aligned to meet domestic requirements. A moderate export surplus of about 10,000 tons is reported to have been sold to Australia and New Zealand.

Supplies of Scandinavian and Continental recovered sulphur appear to be fully taken up by domestic consuming industries of these countries. No offers are reported.

Based on incomplete data it appears that during 1954 the free world supply position was as follows :—

	Production.	*Consumption.*
	Million tons.	
Elemental sulphur ...	6.9	6.5
Sulphur in pyrites ...	4.9	4.8
Other	1.6	1.6
	13.4	12.9

Compared with 1953, total sulphur production appears to have increased 5½% and consumption 2%. The outstanding factor in the favourable supply position was the excess of Frasch sulphur output in the U.S.A. and Mexico over shipments. At the same time, stocks of the Italian sulphur continued to increase.

*See Statistical Appendix.

Expansion of recovery facilities of sulphur in natural, oil refinery, coal, and waste gases enhanced the importance of this source of supply, particularly in the United Kingdom and in Europe. The high level of activity of the chemical industry in the United Kingdom and in Europe exerted strong demand for pyrites, but supplies were adequate.

Outlook for 1955

The supply position in 1955 promises to continue favourably with production increasing about 3% and consumption advancing 2-3%. Frasch sulphur production in Mexico is expected to make the principal contribution to increased supplies.

UNITED STATES SULPHUR

Native Sulphur

DURING 1954, production of Frasch sulphur amounted to 5,515,543 tons, the highest annual total on record, representing an increase of 360,000 tons (7%) over the output of the preceding year, and it exceeds the previous peak output in 1952 by 222,000 tons (4¼%). The rate of production remained fairly uniform throughout the year, monthly totals ranging from a low of 437,449 tons in February to a high of 477,909 tons in December. It was highest during the last quarter, when, aligned to the level of demand, it rose to an annual rate of 5.6 million tons. The principal factors in achieving the continued high rate of production during the year were the successful operations at Garden Island Bay dome of Freeport Sulphur Company which more than compensated the apparent falling off at some of the other domes.

New capacity contributing to 1954 supplies was represented by Nash dome (Freeport Sulphur Company), which, starting in February, is believed to have yielded at an annual rate of 80,000 tons, and Damon Mound (Standard Sulphur Company), which reached its planned capacity of 60,000 tons per annum early in 1954, having started operations in November, 1953. As the result of increased output at Long Point dome, total production by Jefferson Lake Sulphur Company increased by 15%.

	1954 (estimated) *000's tons*	*1953*	*Change*
Texas Gulf Sulphur Company	2700	2776	− 2½%
Freeport Sulphur Company	2100	1766	+19 %
Jefferson Lake Sulphur Company ...	433	376	+15 %
Duval Sulphur and Potash Company ...	220	220	—
Standard Sulphur Company	60	7	8½ times
	5516	5155	+ 7 %

Output of Texas Gulf Sulphur Company is believed to have receded further as the result of reduced output at Boling Dome.

Production of native sulphur from surface deposits during 1954 contributed increasingly to U.S. sulphur supplies. Output is estimated to have totalled about 60,000 tons sulphur in the form of low-grade (25-30% sulphur) ores. Practically the entire output originated from the Leviathan Sulphur Mine of the Anaconda Copper Mining Company, who consumed it in crude form for sulphuric acid manufacture.

Apparent sales of native (Frasch) sulphur during 1954 amounted to 5,310,009 tons, the highest on record, and representing an increase of about 108,000 tons (2%) over 1953, the previous peak year. The outstanding factor in the high level of sales was the tonnage delivered to export markets which remained consistently high during the whole year and totalled about 1.65 million tons, an increase of over 400,000 tons, compared with 1953, and the highest on record.

Deliveries to domestic consumers were affected for more than eight months by the industrial recession and its effect was increased by the concurrent reduction of consumers' sulphur stocks. During the last quarter of the year, domestic consumption improved strongly, mainly as the result of increased sulphuric acid production, which was occasioned primarily by the greater activity in the steel industry—the steel rate rose from 63% to nearly 80%—but also by the seasonal advance in fertiliser manufacture.

Over the whole year acid use by the fertiliser industry was reasonably satisfactory, as total fertiliser production receded only about 2% compared with 1953. Acid consumption by the detergent, petroleum and petrochemical industries was consistently high. Sulphur consumption for non-acid uses was supported by the high level activity in the rubber and pulp industries, whereas rayon output was depressed to about 80% capacity.

Producers' stocks increased by about 200,000 tons, as anticipated. At the close of 1954 they totalled 3,228,020 tons, an increase of 7% during the year, and representing the highest total since 1947.

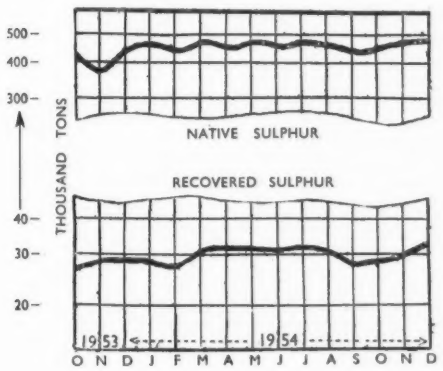


Fig. 9

Recovered Sulphur

Production of sulphur recovered from natural and oil refinery gases in 1954 amounted to 357,400 tons, the highest on record, and representing an increase of about 20,000 tons (6%) over 1953 output. Output in December of 32,200 tons was the highest monthly total in this branch of the industry and it reflects increasing application of gas cleaning and sulphur recovery. Amongst new projects in 1954, operations started at the recovery plants of Columbia Carbon Company at Seminole, Texas—annual capacity of 7,000 tons sulphur—and that of Phillipps Chemical Company at Eunice, Louisiana—annual capacity of 8,700 tons. Apparent sales in 1954, of 355,678 tons, were about 30,000 tons (10½%) greater than in 1953. Recovered sulphur output is wholly taken up by U.S. domestic consumers and demand is subject to seasonal fluctuations. Offtake in November was exceptionally low, under 20,000 tons, and in consequence, the apparent sales for the fourth quarter of 78,273 tons, were appreciably lower than during the corresponding period of 1953. Stocks at the end of the year totalled 109,066 tons, showing a small (1½%) increase over the tonnage so held one year earlier.

Other Sulphurous Raw Materials

It is estimated that production of sulphur in other forms totalled 785,000 tons, an increase of 7½% compared with 1953. The total is made up as follows:

	1954	*1953*	*Change*
	000's tons		
Sulphur in pyrites	419	380*	+10½%
Sulphur in smelter gases	306	290	+ 5½%
Sulphur in by-product acid from hydrogen sulphide	55	55	—
Sulphur dioxide in liquid form from smelter gases	5	5	—
	785	730*	+ 7½%

*Amended.

The start of by-product sulphuric acid operations at the works of Eagle-Picher Mining & Smelting Company, at Galena, Kansas, and Bunker Hill and Sullivan Mining and Concentrating Company, at Kellogg, Idaho, adds two important producers to this source of sulphur supply.

The salient points in the developments of the U.S. sulphur industry during 1954 are thought to be as follows :

a) Production of Frasch and recovered sulphur in 1954 was the highest on record, amounting to 5,872,943 tons or nearly 7% (380,000 tons) greater than in 1953.

b) Apparent sales of Frasch and recovered sulphur in 1954 of 5,665,687 tons, also the highest on record, were 2½% (140,000 tons) greater than in 1953. Whereas export shipment rose about 400,000 tons to 1.65 million tons, apparent domestic consumption receded nearly ¼ million tons to just over four million tons, although reduction of consumer stocks is believed to have resulted in actual consumption of 4.1-4-2 million tons.*

c) Producers' stocks of Frasch and recovered sulphur totalled 3,337,086 tons at the end of 1954, an increase of over 200,000 tons during the year. This level of stocks is estimated to represent domestic consumption for about 9½ months.

The supply prospects for 1955 were recently summed up by Mr. Langbourne M. Williams, President of Freeport Sulphur Company :

"With productive capacity already at an all-time high and with further gains in prospect, the U.S. sulphur industry begins the new year in a strong position to meet all the demands upon it. There should be ample sulphur to supply in full the needs of consumers both at home and abroad."

In this connection it is thought unlikely that in 1955 total output of Frasch sulphur will show a substantial increase over current levels. Additional dome capacity that is expected to come into operation this year, such as Freeport's Chacahoula dome and Standard Sulphur Company's Allen dome and expansion at Damon Mound may only make up for the reduced output of old or uneconomic wells. Development and exploration work is in progress by Texas Gulf Sulphur Company at Lake Bullicamp near Houma, Louisiana, and Fannett dome near Beaumont, Texas, by Duval Sulphur Company at High Island dome, and by Jefferson Lake Sulphur Company, Lone Star Sulphur Company and The Sulphur Exploration Company. These may provide an indication of their probable scope, but are unlikely to affect the 1955 production. Expansion of recovered sulphur output is expected to continue, though at a slower rate than hitherto. In view of the general improvement of the economic climate in the U.S.A., reflected by an anticipated 4% increase in the output of the chemical industry, domestic consumption of sulphur is expected to rise. Increased activity in the sulphuric acid industry is likely to result from greater requirements for iron and steel making, and by increased demand for the manufacture of fertilisers which is expected to return, at least, to the 1953 peak level.

The rayon industry, which accounts for about 7½% of sulphur use in the form CS_2 or acid, has been in the doldrums throughout last year, although in recent months there have been signs of improvement, notably in the output of high tenacity yarn and staple fibre. Sulphur usage by the rubber industry is expected to rise 4-5%. It is expected that U.S. elemental sulphur production in 1955 will be at least 5.9 million tons,

*For details of consumption see Statistical Appendix.

which would enable producers to make some additions to stocks, although, in view of continuing high export demand and increased domestic consumption, at a lower rate than in 1954. As it remains the Government's wish that mines' stocks be raised to four million tons, producers may, however, deem it opportune, in the prevailing favourable world supply position, so to adjust their sales that a more rapid rate of stock accumulation can be achieved.

JEFFERSON LAKE SULPHUR COMPANY

IN a personal message, preceding the Annual Report for 1954, the President, Mr. Eugene H. Walet, Jr., reviewed the activities and progress of the company in its most successful year, both financially and as regards sulphur production. In his assessment of the world sulphur situation and its impact on the company, which maintained its position as the third largest brimstone producer in the world, the President, amongst other things, concluded :

"*Therefore, we believe that the demand for and consumption of sulphur will continue on an upcurve, with normal periodic hesitations, levelling out and dips, whether we have intensive defensive effort or desired peace-time economy. We do not anticipate a harmful over-supply from the expansion and conservation programmes and new sulphur projects in this country and other parts of the world. However, we definitely will have a competitive market for the immediate future. Sales success will require two fundamentals — quality product and the right price.*"

The graph depicts the developments at the company's three domes, for the period 1937-1954.

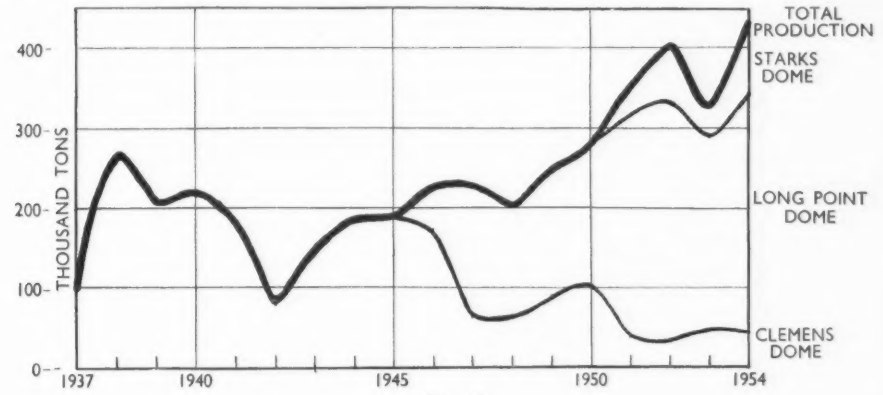


Fig. 10

Production Frasch Sulphur

During 1954, production amounted to 433,500 tons, the highest in the company's twenty-six years' existence, and 15½% greater than in the preceding year. Details of production of the company's individual domes are as follows :—

	1954	1953	1952	Change a)	Change b)
		Tons			
Clemens	96,100	98,500	84,300	−2½%	+14%
Long Point	249,200	190,000	249,300	+31%	—
Starks	88,200	87,400	71,800	+1 %	+23%

a) Comparison of 1954 output with that of 1953.

b) Comparison of 1954 output with that of 1952.

Production, it is stated, was obtained from virtually the same areas which have been in production for some time, and recoveries of sulphur have exceeded the original estimates of available sulphur.

Recovered Sulphur

The company's sulphur extraction plant at Manderson, Wyoming, is completed, and production is believed to have started, as scheduled in February. The plant reduces to elemental sulphur, concentrated hydrogen sulphide, delivered to the company under long-term contracts with Socony-Vacuum and other oil companies, who recover it from natural sour gas in a plant adjacent to Jefferson's sulphur extraction plant. Its capacity is 130 tons per day sulphur, later to be expanded to 300 tons per day.

Sales and Shipments

Total shipments during the year amounted to about 407,000 tons, of which, 261,809 tons—2% less than in 1953—were sold on the company's own account, the balance, on account of Texas Gulf Sulphur Company.

Comparative details of the company's shipments are shown in fig. 11.

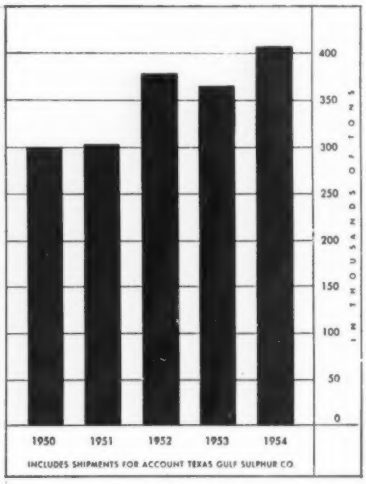


Fig. 11

Output is believed to have consisted wholly of bright sulphur, and sales were based on $28.50 per ton ex-mine for domestic sales and $33.00 f.o.b. Gulf port for export.

Notwithstanding the record level of shipments, the company's stocks appear to have increased by up to 25,000 tons.

Finance

Net operating profit amounted to $2,578,945, which was augmented to $3,202,799 by a non-recurring item accruing as the result of successful litigation. After tax payment of $1,019,000, the company's net income was $2,183,799, the highest on record, which compared with $1,486,762 in 1953, the previous peak year. Dividend payments on common shares were increased from $1.05 in 1953 to $1.30 after payment of 70 cents on preferred shares as previously.

Projects

Fertiliser Plant

Plans are nearing completion for the construction of an acid and triple superphosphate plant at Montpelier in South-Eastern Idaho. Production of acid is to be at an annual rate of 80,000 tons using sulphur recovered at the company's plant at Manderson. Using local phosphate rock, the output of a similar tonnage of triple superphosphate is envisaged.

Exploration

The company has acquired sulphur rights on a shallow dome on the Gulf cost area where previous wells have indicated the presence of sulphur and a typical caprock formation. Exploration is to start in the near future.

Other Activities

Satisfactory progress is reported in connection with the company's research and development work on equipment "Rotabsorber" for recovery of liquifiable hydrocarbons and dehydration and recovery of hydrogen sulphide from sour natural gas. The promising activities of the associated Merichem Company, which manufactures cresylic acid and sodium sulphide at a plant near Houston, may lead the company to branch out more actively in the field of petrochemicals.

Summary

The high rate of the company's Frasch sulphur production is to be supplemented by sulphur recovery from natural gas, while at the same time, exploration of new dome properties is designed to safeguard the company's established activities. In spite of its age, Clemens dome has maintained the level of production of recent years.

Off-Shore Sulphur

AS reported earlier*, the Humble Oil Company are engaged on an exploratory programme to prove the extent and nature of the off-shore dome deposit struck last year in the Gulf of Mexico.

We are indebted to Mr. Morgan J. Davis, Vice-President of the Company, for the following account of operations.

The sulphur-bearing cap rock at the salt dome is found at depths ranging from about 1,700 to 2,000 feet below sea level, and in an area of several hundred acres.

The exploratory work designed to procure cores from representative sections of the dome is being effected from the Delong drilling barge, shown in the photograph. This consists of a hull,

DeLong drilling barge at Humble Oil & Refining Company's No. 3 sulphur core test, Grand Isle Block 18 salt dome. A tug boat and materials barge are alongside, and space for helicopter landings is provided on the right-hand end of the barge deck. Since this photograph was taken an elevated and enlarged flight deck has been installed.

about 70 feet wide by 200 feet long, which contains all drilling and other equipment required in the core testing operations. It is supported by two rows of moveable caissons six feet in diameter and 180 feet long, that extend through the hull along each side. At the drilling site, the caissons are lowered through the hull into the Gulf of Mexico. Air jacks are then used to penetrate about 50 feet into the bed of the Gulf, to support the drilling barge and equipment. When the caissons are secure, the barge is raised by the jacks to about 40 feet above sea level, where it is protected from storm waves. It is then securely locked in place to provide a platform for drilling operations.

After a test well has been completed, the barge is lowered into the water, the caissons are pulled up, and the barge is then towed to the next drilling site. Materials are moved by boats, and the drilling crews reach the barge by boats or helicopters.

Coring is done with a diamond bit and special barrel, otherwise standard rotary drilling equipment is used. The diameter of the cores is $5\frac{1}{4}$ inches, and, to obtain a good recovery, the core barrel is brought to the surface after short intervals of between five and ten feet have been cut. Since from 300 to 600 feet are cored in each test, about three to four weeks are required to complete one.

It is reported that a very good recovery of the sulphur-bearing formations is being secured, and that the results from eight sulphur tests drilled up to the end of last year indicate that a sulphur deposit worthy of commercial exploitation exists at this salt dome.

The company, which has extensive experience of off-shore oil and gas production, is now engaged in examining the problems which this novel enterprise involves. It is as yet too early to assess the likely capital and production costs, although it is thought that they could be as much as two to three times greater than comparable land-based operations at the larger deposits.

*Quarterly Bulletin No. 5, p. 55.

Sulphur in Italy

Early in March the difficulties of the Italian sulphur industry, which have been accumulating for the past two years, reached an openly critical stage, ostensibly due to the lack of decisive government guidance and adequate financial support which the industry had been anticipating.

At first, the owners of Italy's 360 sulphur mines announced that on 20th March, 1955, they would shut down operations due to lack of government aid. This was countered by the sulphur miners, some 10,000 strong, mostly affiliated to the communist-controlled General Confederation of Labour (CGIL) that on 18th March they would occupy all mines to prevent the lock-out. This declaration followed a series of local stay-in strikes over the past months which had been occasioned by wage claims. In the case of the dispute at the Riesi mine, in which about 1,300 miners were involved, they claimed that over the past year only 23% of the agreed wage had been paid and that each were owed by the company some L.400,000 (£230).

At this stage, the government intervened and, following the approval of a bill providing financial aid to the industry, the mine owners reversed their original decision. The bill is reported to include provision for the increase of the loan funds for the modernisation of plant and the reorganisation of production from 9 billion to 12 billion Lire, and for the payment of a subsidy of L.10,000 per ton (£5¾) to offset losses on sales made after implementation of the new law, from supplies put at the disposal of the Ente Zolfi Italiani. A ceiling—330,000 tons—limits the quantity of sulphur on which this subsidy would be payable.

In addition, the Ministry of Industries is to make a grant of 1.15 billion Lire to the Sicilian Local Administration intended to permit payment to mine owners to help offset production costs.

In conjunction with the bill, which is still to be passed by the Italian Parliament, a measure was approved by the Regional Assembly on 17th March, 1955, under which the Banco di Sicilia may grant extraordinary loans of up to 500 million Lire for the purpose of paying wage arrears. The total back pay claimed by the trades union for 1954 is believed to exceed 1,000 million Lire.

In a recent statement the Ente Zolfi Italiani have expressed great satisfaction with these new measures on which they comment as follows :—

> *"It will certainly permit the realisation of further programmes for the modernisation and the development of the Sicilian sulphur mines. This could be achieved by the improved organisation of the plants and of the transportation ways underground, and especially by the adoption of more economical methods for mining sulphur."*

The level of new export prices which is to be determined by the Government has not yet been announced. So far no details are available of plans for the reorganisation of the industry. Until they are known, the danger persists that in view of the conflicting sectional interests, they may lack decisiveness and thus turn the financial aid into yet another palliative.

In 1954 Italian production totalled 204,040 metric tons, 8½% less than in 1953. Deliveries totalled 115,808 metric tons, of which all but about 800 tons were taken up by domestic consumption, which was about 33,000 tons greater than in 1953. Sulphur stocks at the end of 1954 are estimated to have totalled 310,000 tons.

The Sulphuric Acid Industry in Poland

(Based on information contained in a Review of the Chemical Industry of Poland in "Die Welt Chemie-Wirtschaft," published by "Chemische Industrie" in December, 1954).

General

BEFORE the war, 64% of Poland's sulphuric acid manufacture was based on the use of sulphur in lead and zinc smelter gases, and 36% on that of marcasite and pyrites, the latter being to a large extent imported from Scandinavia. Production was almost entirely carried out by the chamber process, and the acid produced was nearly all in the form of 50° Bé. After the war, development of the industry was hampered by the lack of raw materials and the necessity to rebuild plants, following the extensive war damage. Under the first six-year plan of the Polish Planning Commission (1949-1955), it was decided to replace a number of the old chamber plants by the Russian continuous tower process, and the conversion, with Russian aid, was essentially completed by the middle of 1953. This development, coupled with the construction of new plants, incorporating tower or contact acid units, resulted in the following changes :—

Acid production from :	*1949*	*1953*
	%	%
Chamber plants	34	10
Tower plants	44	50
Contact plants	22	40

By 1960, it is planned to have as many contact as tower plants in the country, and the conversion of the sulphuric acid works at Torun will contribute to this development.

Between 1949 and 1953, the standard of efficiency in the industry was raised, and the experience at four selected plants listed below, all of which use pyrites as raw materials, are said to be indicative of the general improvement.

Production

At the same time, the reconstruction of sulphuric acid plants based on zinc blende and pyrites were supplemented by the construction of plants based on anhydrite, which are intended to provide a progressively larger share of Poland's acid requirements.

Because of the limitations of indigenous pyrites resources, the unlikelihood of increased acid output from smelter gases and the political leaning of the country towards increased self-support, the Polish Planning Commission decided in 1949 that the country's expanding needs for sulphuric acid should be met as far as possible from the vast reserves of high quality gypsum and anhydrite which exist in Silesia and Western Poland. This decision led to the construction of two new major anhydrite acid plants at Wizow and Busko. The first, Wizow, was completed in 1951, but, as will be seen from the table (P. 30), it is expected to provide only about 80,000 tons, or 15% of the country's output this year. When it reaches full capacity of 180,000 tons a year, it will be the largest of its kind in the world. The plant at Busko, similar to that at Wizow, is not yet in operation, but is due to reach maximum capacity by 1960. A third anhydrite plant is provided for in the 1955-1960 plant, in the Rzeszow area.

Kilograms

Works	*1949*		*1951*		*1952*		*1953*	
	a)	*b)*	*a)*	*b)*	*a)*	*b)*	*a)*	*b)*
Gleiwitz ...	10.6	75	12.9	106	47.9	135	52.7	150
Waldenburg ...	10.6	96	12.9	110	47.9	130	52.7	150
Stettin	12.3	70	36.6	93	22.0	96	40.3	112
Posen	6.7	107	6.2	121	10.9	128	36.5	133

(a) Acid yield per cubic metre per 24 hours (rated capacity for each plant 60 kilos per cubic metre per 24 hours).
(b) Tonnage of pyrites roasted per square metre of roasting surface per 24 hours.

The recovery of the sulphuric acid industry after the war, and the changes in the use of sulphurous raw materials, are indicated by the output figures for the period 1946-1954 :—

Date	Production 000 tons H_2SO_4	From raw materials (%) Zinc blende	Pyrites	Anhydrite
1946	124	75.5	24.5	—
1949	278	45	55	—
1951	320	43	52	5
1952	400	35	56	9
1953	415	33	54	13
1954 *(Plan)*	470	30	56	14
1955 *(Plan)*	540	29	56	15

The production of by-product sulphuric acid from smelter gases, which, in the past, has played a very important part in meeting Poland's acid requirements, is not expanding with the other branches of the acid industry. Although the six-year plan provided for the expansion of zinc metal production to 197,000 tons, this does not appear to be very probable. In 1953, output of zinc was only 100,000 tons, 10% less than the 1938 figure. It is believed this may be due to shortage of available zinc ore supplies. The use of sulphur in zinc blende now provides one-quarter of Poland's acid requirements. At present, the use of pyrites accounts for more than half of Poland's sulphuric acid output, but its share is likely to decrease in the near future. Production from anhydrite is expanding steadily and this year's planned output of acid from all sources—540,000 tons—should be reached.

Consumption

In view of the general increase in industrial activity in the country since the war, the requirements for sulphuric acid are now not only greater, but also more diverse. Large increases in consumption are believed to have taken place in the metallurgical industries, notably iron and steel, and in the heavy chemicals industry for the production of hydrochloric acid, bichromates and metal sulphates. The expansion of the viscose rayon industry on the basis of existing plants installed by the Germans in Western Poland (formerly Germany) has also substantially raised sulphuric acid requirements. At least eight large rayon and fibre works are known to be in full production.

The principal need for sulphuric acid in Poland is for the production of fertilisers, particularly superphosphate. Before the war, Poland had sixteen superphosphate works with an aggregate annual capacity of 800,000 tons of 16% grade. About 80% of the capacity was unused, however, and in 1937, it was recorded that output was only 160,000 tons. Some of these plants suffered war damage, but the addition of former German territory gave Poland a number of superphosphate plants which had a pre-war capacity of 490,000 tons. Today there are twelve large superphosphate plants with a total capacity of about 1.3 million tons, but these are still not worked to the full. Actual output of phosphatic fertilisers has risen from 72,000 tons (P_2O_5 content) in 1949 to 94,300 tons in 1953, the bulk of the production resulting from imported phosphate rock. The planned output for 1955 is 250,000 tons. Since autumn, 1953, granulated superphosphate has been made at a plant at Lubon, near Posen, and 100,000 tons are expected this year. The demand for superphosphate is considerably higher, and much is imported from the U.S.S.R. The slow rate of production of superphosphate has been due to the lack of sulphuric acid, which has led to phosphatic fertiliser production by alternate means, notably fused phosphate rock and to a lesser extent nitrophosphate. At the chemical works in

Chorzow, a phosphatic fertiliser (Supertomasyna) is now being made by smelting in an electric furnace a mixture of raw phosphate, sand, and soda. The following table shows actual and planned capacities :—

	1953		1955 (Plan)	
	(P2O5 tons)	% of total	(P2O5 tons)	% of total
Superphosphate ...	73,000	77.4	169,800	67.9
Supertomasyna ...	17,150	18.2	53,500	21.4

Ground phosphate and nitrophosphate provide the balance of supplies, bone meal and basic slag not being included in these figures.

In 1938, production of nitrogen for fertiliser and industrial uses amounted to 54,000 tons, of which ammonium sulphate represented about 8%. In 1953, output of by-product ammonium sulphate was about 78,000 tons, or nearly four times the pre-war figure, and accounted for about 18% of total output of nitrogen.

Conclusion

The effects of the reconstruction programme have been apparent since 1953, and Poland's sulphuric acid industry, based on anhydrite, pyrites, and smelter gases, is now well on the way to meeting its domestic needs. So far elemental sulphur has taken no part in the development of the industry. The main needs of such sulphur in the country, where the chemical industry is rapidly expanding, are for carbon disulphide in the rayon industry, for the manufacture of insecticides, dyes and ultramarine, and for the vulcanisation of rubber. Elemental sulphur for these industries has been mainly imported from Italy and Eastern Germany. Two years ago, however, extensive deposits of this raw material were found in the neighbourhood of Zandomierz, from which it is estimated that in the near future an annual production of about 200,000 tons could be achieved. If so, even allowing for a substantial increase in non-acid requirements, there would be a considerable surplus available for export, or for use in sulphuric acid manufacture. Poland's sulphuric acid production has already doubled since before the war. The emphasis in the development plan of the Polish industry is on the further expansion of the iron and steel, petrochemicals, and heavy chemicals industries. In these, the increased supplies of sulphuric acid will inevitably play a major rôle. It is reported that by 1960 acid production from anhydrite is to account for 57.1% of total production, which it is believed is then planned at 800,000 tons a year.

Sulphur in O.E.E.C. Countries

THE latest report of the Chemical Products Committee concerns the position of sulphurous raw materials in the member countries during the first six months of 1954. The following developments took place in the period under review*:

Native and Recovered Sulphur

Production of elemental sulphur totalling 233,700 tons, supplemented by imports of 372,000 tons, was more than adequate to meet consumption of 483,600 tons and exports of 41,800 tons, in spite of about 34,000 tons of Italian production—the entire export surplus—being added to producers' stockpile owing to their inability to sell at competitive prices. The increase of consumers' stocks represents only about a fortnight's consumption.

Elemental sulphur uses showed the following changes compared with earlier periods :—

*All quantities are expressed in metric tons.

	1st half 1954 %	2nd half 1953 %	1st half 1953 %
Sulphuric acid	35	38	39
SO_2	13	17	15
CS_2	26	25	26
Agriculture	17	6	13
Other	9	10	7
Total sulphur (000's tons)	483.6	395.4	415.3

The absolute increase of acid sulphur use is significant.

Pyrites

Production of pyrites amounted to 831,500 tons (sulphur content) as against consumption of 1,364,000 tons and exports to other countries of 23,300 tons. Owing to the discrepancies in reported import figures—imports from Cyprus appear to be understated by about 90,000 tons and whereas imports from metropolitan members are reported as 313,700 tons corresponding exports are given as 215,300 —estimates of changes in stocks might be misleading. Notwithstanding these discrepancies, supplies appear to have been adequate to meet requirements.

Zinc Blende

Production of sulphur in zinc blende amounted to 69,400 tons. Reported imports from overseas territories of 30,500 tons and from other countries of 72,500 tons appear to have been inadequate to meet consumption of 205,600 tons.

Sulphur in Other Forms

Production and consumption of sulphur anhydrite, spent oxide and mine wastes were approximately in balance; trade in these materials was negligible. Export figures of sulphur in spent oxide from the United Kingdom to the Continent are not balanced by corresponding import figures.

Thousand Metric Tons

	PRODUCTION*		Change	CONSUMPTION*			Change %	
	July-Dec. 1953	Jan.-June 1954	%	Jan.-June 1953	July-Dec. 1953	Jan.-June 1954	(a)	(b)
Native Sulphur ...	123.5	102.7	-17	—	—	—	—	—
Recovered Sulphur...	127.8	131.0	+ 2.5	—	—	—	—	—
Total Sulphur ...	251.3	233.7	- 7	415.3	395.4	483.6	+ 16.5	+ 22.3
Pyrites	873.8	831.5	- 5	1,154.7	1,274.9	1,364.0	+ 18.3	+ 7
Blende	68.7	69.4	+ 1	184.0	191.2	205.6	+ 11.7	+ 7.5
Others	295.5	294.7	—	255.4	290.0	288.6	+ 13	- .4
TOTAL ...	1 489.3	1,429.3	- 4	2,004.2	2,151.6	2,341.8	+ 16.9	+ 9
Sulphuric Acid ...	4,656.6	5,022.2	+ 7.8	4,380.1	4,678.6	5,024.0	+ 12.4	+ 7.4

(*a*) ***Increase/Decrease compared with 1st half, 1953***

(*b*) ***Increase/Decrease compared with 2nd half, 1954***

*See also Statistical Appendix.

Sulphuric Acid

Production and consumption were in approximate balance at a level of about 5.02 million tons. Acid uses showed the following small changes compared with earlier periods :—

	1st half 1954 %	*2nd half 1953* %	*1st half 1953* %
Fertilisers	55	54	57
Textiles	11	11	10
Metallurgy	4	4	4
Other	30	31	29
Tons (100% H_2SO_4) ...	5024	4679	4380

In the table on p. 32, the details of production and consumption during the first half of 1954 of the various sulphurous raw materials are compared with earlier periods and based on these data, the report concludes as follows :—

Total production of sulphur materials by member countries during the first half of 1954 was 4% lower than in the second half of 1953, whereas consumption was 9% higher. The increase in consumption, by tonnage, was almost identical for sulphur and pyrites, the consumption of other sulphurous raw materials having remained relatively stable.

Sulphuric Acid Production from Hydrogen Sulphide

DURING recent years considerable attention has been focussed on the possibility of recovering in some usable form the sulphur contained in coke oven gas and certain refinery gases. As a consequence there has been a great deal of development work carried out on plants for the recovery and subsequent utilisation of hydrogen sulphide, in which form the sulphur is mainly present.

It is the intention in this issue to give a general review of the position with some detailed information concerning recent developments in the wet contact sulphuric acid process, which is one means of producing a marketable heavy chemical from the H_2S. In later issues of this Bulletin it is hoped to give rather more detailed accounts of the different types of H_2S desulphurisation plants and also plants for the production of elemental sulphur.

At the present time there are a variety of plants available for removal of H_2S from gases and these fall naturally into two classes ; those suitable for the coal gas industry and those suitable for the petroleum refinery industry. Generally speaking the problems met in these two major industries are so different that desulphurisation plant development has been to some extent on rather different lines.

In the petroleum industry liquid processes are used and the various plants available have been described in detail in technical literature. During the Special Study of Sulphur Removal and Recovery from Fuels, held by the Institute of Fuel in London last October, a paper (No. 11) read by Messrs. Brockwell and Rixon included an account of various types of desulphurisation plant used for gases other than coal gases. A typical plant of this type uses an amine solution for absorption of H_2S and CO_2 and the acid gases are recovered from the solution by heating. Deserving special mention in this connection is the vacuum carbonate process, which, although developed to deal with coal gases, is now being used for gases derived from petroleum, which are eventually to be used as town gas, since their analysis may not be suitable for the amine (Girbotol) type of plant.

During the study referred to above various papers (6, 7, 8, 9, and 10) were also read, giving an account of methods

for removal of H_2S from coal gases. The oxide method of purification used in the gas industry and certain other well-known wet processes (Thylox, Staatsmijnen—Otto) recover the sulphur in elemental form, but recently a great deal of attention has been given to the development of desulphurisation processes using ammonia liquor as the absorbing medium. Many plants have been erected in Germany and elsewhere on the Continent and there is considerable interest in this country. Details of the only plant at present in operation in the U.K. have been published by T. H. Williams (Paper 10 of Special Study and Coke and Gas, February, 1954). This particular desulphurisation plant was designed by Collin G.m.b.H., of Dortmund, but recently other Continental organisations have made arrangements which will permit their particular plant design to be available in this country. These firms are Coppee and International-Carl Still, of London, Balfour-Lecocq, of Leeds, and Didier Kogag, of Stockton-on-Tees, and in addition there are other Continental firms with their own special designs.*

All these ammonia processes give an acid gas containing probably about 50-80% H_2S, and the possible methods of use are the same as for acid gases obtained from Girbotol or other types of desulphurisation plant.

In the petroleum industry conditions are frequently such that the production of elemental sulphur from H_2S is more attractive than the direct production of sulphuric acid. Generally speaking the petroleum companies are loath to enter the heavy chemical industry and if possible would probably prefer to dispose of their recovered H_2S in the manner carried out at the refinery of the Shell Group at Pernis in Holland. Here desulphurisation is effected by the Shell phosphate process and the H_2S is disposed of to an adjacent works of Albatros Superfosfaat-fabrieken N.V. for production of acid.

The modern method of producing elemental sulphur from H_2S is a development of the old Claus process and depends on oxidation by atmospheric air in the presence of a bauxite or special alumina catalyst. There are now numerous variations in detail between plant developed by different designers, but the process still remains essentially that pioneered by Claus.

In the field of sulphuric acid production direct from H_2S, a simple type of unit to utilise H_2S in gases from ammonia saturators was developed in Germany and in recent years considerable advances have been made in technique so that plants can now be offered to deal with gases containing any concentration of H_2S above about 18%. In outline the process consists in combusion of the H_2S in atmospheric air at a temperature of 1000°-1200° C. The hot gas containing SO_2 and water vapour is cooled (usually in a waste heat boiler) and passes direct to a converter, where the SO_2 is oxdised to SO_3 in the presence of a vanadium catalyst. The SO_3 and water are condensed in a special tower in which acid is circulated. The exit gases are freed from acid and mist by electrostatic precipitators or other means.

This process is essentially different from the normal contact process for production of sulphuric acid since no attempt is made to dry the gases before conversion. In the normal process great care is taken to ensure that the reacting gases are absolutely dry. Development of the "wet contact" process was only possible when improved vanadium catalysts were made which could deal with the wet gases; but the essential difficulty in the process is the absorption of the SO_3. Dry SO_3 is readily absorbed by 98% H_2SO_4, but in the presence of moisture, acid mists are formed, and these are stable and difficult to remove. Early attempts at direct condensation of the gases encountered difficulties with materials of construction, but it is now usual practice to employ a condensation tower, rather similar to the absorption

*The type of plant designed by Lurgi G.m.b.H. was described in Bulletin No. 6, page 44.

tower of a "dry" contact plant, but the acid in circulation is maintained at 78% strength. It should be mentioned that owing to the fact that the H_2S gas and combustion air are not dried and due also to the presence of water from the combustion reaction, the proportions of SO_3 and H_2O will be such that 98% H_2SO_4 cannot be obtained. In many cases the water balance is such that it should be theoretically possible to produce say 85%-90% acid. However, it is difficult to select materials of construction for such conditions and in practice additional water is added to the circulation acid to maintain 78% strength.

A plant of this type is shown on the flow diagram (fig. 12), and in the photograph of the Albatros Superfosfaat-fabrieken N.V., Holland. It can utilise the H_2S gas from any of the established processes for desulphurisation.

As an example of the wide application of this plant a list is given below of recent installations showing the source of H_2S gas in each case.

Albatros Superfosfaat-fabrieken N.V., Pernis, Holland	43 tons/day 78% sulphuric acid	H_2S gas from Shell Phosphate Recovery Plant
Zeche Minister Achenbach, Dortmund, Germany	5 tons/day 78% acid	H_2S gas from ammonia saturators
Stewarts and Lloyds, Ltd., Corby ...	43 tons/day 78% H_2SO_4	H_2S gas from Collin ammonia type desulphurisation plant
Dr. C. Otto G.m.b.H., for San Nicolas Coke Ovens, Buenos Aires	13.5 tons/day 78% H_2SO_4	Otto plant for H_2S recovery
Berlin Gas Works	50 tons/day 78% H_2SO_4	H_2S gas from Carl Still plant or sulphur from spent oxide

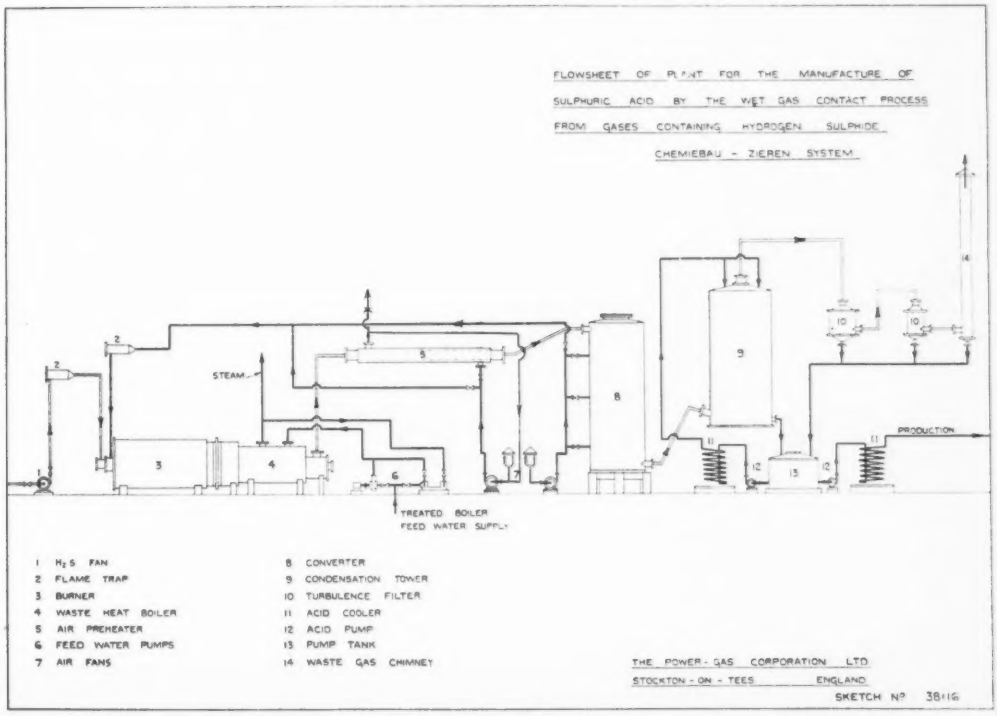
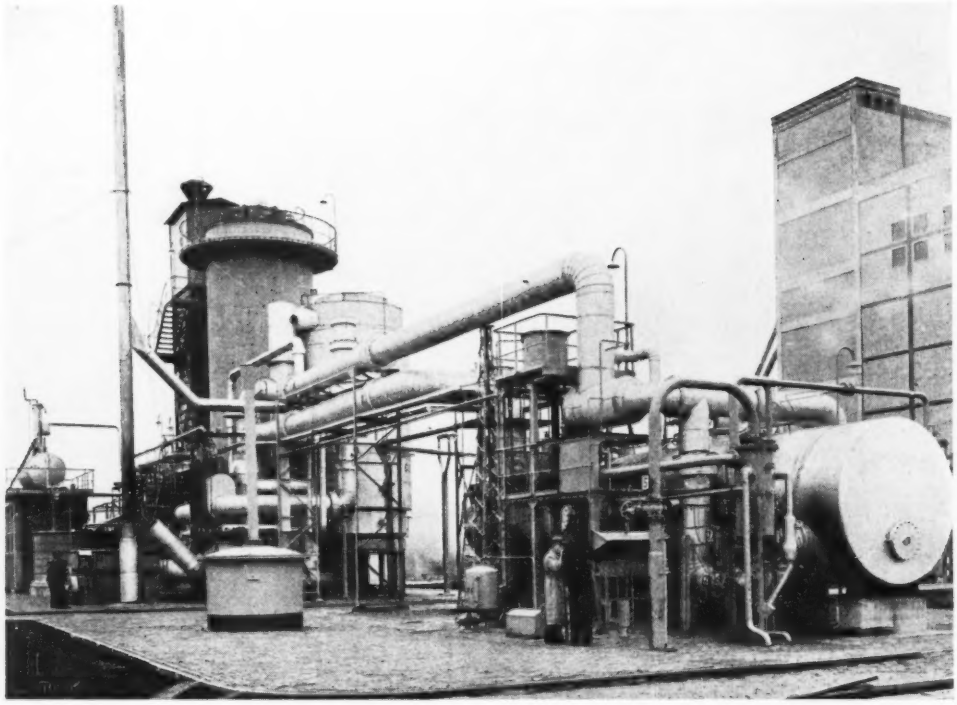


Fig. 12

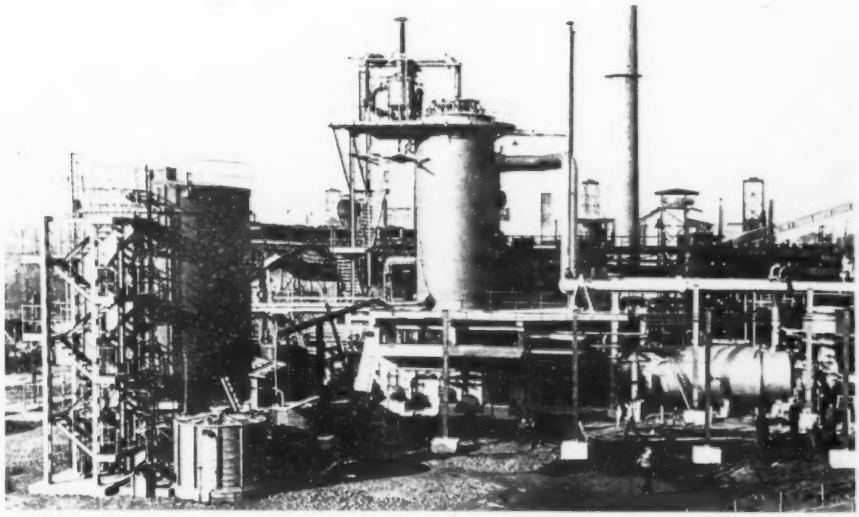


Sulphuric acid plant of Albatros Superfosfaatbrieken N.V., Pernis, Holland, showing from right to left: combustion furnace and waste heat boiler, converter, condensation tower and electrostatic precipitation.

The installation at Berlin Gasworks is of particular interest, since it is designed to work on H_2S gas, impure sulphur containing tar, or on mixtures of these two raw materials. Previously the impure forms of sulphur derived from some desulphurisation processes were of very little value and substantial quantities were dumped. The wet contact process offers, therefore, a means of utilising other cheap forms of sulphur in addition to waste H_2S. The actual H_2S gas for this particular installation contains about 40-50% H_2S and 4% hydrogen cyanide (HCN).

The presence of HCN in the acid gas is usual in coke oven plants and during the combustion process this is oxidised to nitrogen and oxides of nitrogen. The latter are eventually absorbed in the circulating acid and may result in a nitric acid content of the production acid of up to 0.2%. In Germany this has caused little interest and acid from wet contact plants (and also from chamber plants containing similar amounts of nitric) has been used for the manufacture of sulphate of ammonia without, apparently, any difficulties being encountered. In this country it is widely held, however, that in order to make Grade I sulphate a very low nitric content is essential. Removal of the nitric acid down to reasonable limits is, however, possible without adding unduly to the cost of the process and this is, in fact, carried out at Corby.

The question of steam credit is particularly important in assessing the overall operating cost of a wet contact plant and in one case it has been stated that the steam credit covered the normal operating costs of the plant, although such favourable conditions do not always obtain. The economics of the process are very favourable even when the amount of sulphur which can be



Berlin Gas Works. Wet contact acid plant.

recovered is only equivalent to about 5 tons of 78% acid per day.

The production of 78% acid is in some cases a disadvantage of the simple wet contact process and where 98% acid is essential the type of plant shown in flow diagram (fig. 13) is required. The capital costs of such a plant are naturally higher than the wet contact unit since the gas has to be cooled, dried, and then re-heated before conversion. It is, however, lower than the combined cost of Girbotol plant and a normal dry contact sulphuric acid plant. It might, therefore, be expected that a plant of this type would be of interest where H_2S is available and there is a market for 98% acid. Such conditions obtained at Staatsmijnen-in-Limburg and the plant has been in operation for some years utilising H_2S from vacuum carbonate installations.

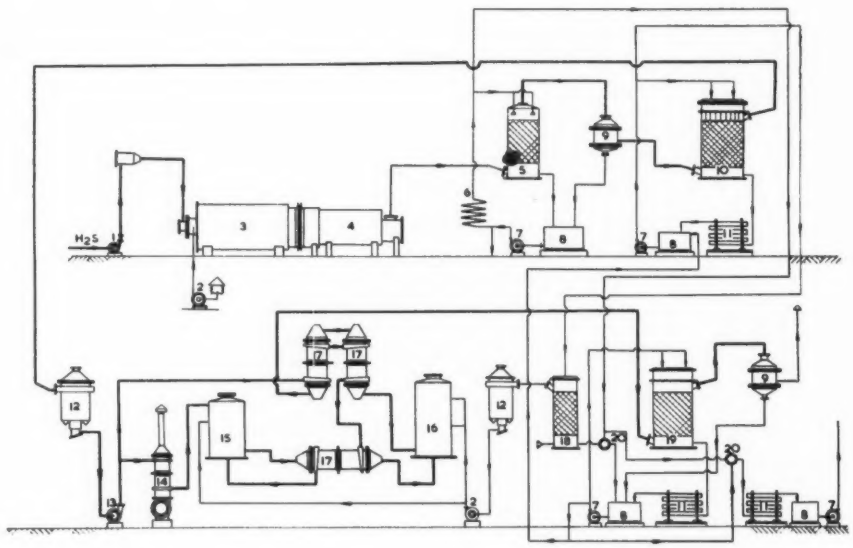
A further possibility for the utilisation of the H_2S gas is the production of 78% acid by means of a tower type plant, e.g., the Hibernia works at Wanne Eickel, Germany, producing 30 tons acid per day.

Although the capital cost of the tower type plant is also rather higher than the wet contact unit, certain operators who have had experience with these plants prefer them from the operating point of view. In this particular case there is an advantage in operating costs as compared with the standard type of tower plant based on pyrites or spent oxide, since the cyanides in the H_2S gas burn to oxides of nitrogen, thereby reducing the amount of nitric acid which otherwise has to be introduced into the system.

The practical developments of processes making use of sulphur contained in coke oven and other industrial gases have shown that they permit low cost sulphuric acid production and result in gases being rendered relatively sulphur free. These economic advantages are reinforced by the contribution of such practice to the abatement of air pollution, and they point to the increasing scope of a source of sulphur that has hitherto largely gone to waste.

We are indebted to The Power-Gas Corporation, Ltd., for the information that they kindly placed at our disposal. The flow diagram and illustration refer to plant designed by the German engineers Chemiebau Dr. A. Zieren G.m.b.H., of Nieder Marsberg W.G., who are now working in conjunction with The Power-Gas Corporation, Ltd., of Stockton-on-Tees.

PLANT FOR THE MANUFACTURE OF 98% SULPHURIC ACID
BY THE CONTACT PROCESS
CHEMIEBAU-ZIEREN SYSTEM
RAW MATERIAL - GASES CONTAINING H_2S



1. H_2S BLOWER
2. AIR BLOWER
3. COMBUSTION FURNACE
4. WASTE HEAT BOILER
5. COOLING & WASHING TOWER
6. COOLER
7. PUMPS
8. PUMP TANK
9. TURBULENCE FILTER
10. DRYING TOWER
11. IRRIGATION COOLER
12. ACID SEPARATOR
13. SO_2 BLOWER
14. GAS PRE-HEATER
15. PRIMARY CONVERTER
16. SECONDARY CONVERTER
17. HEAT EXCHANGER
18. AIR DRYING TOWER
19. ABSORPTION TOWER
20. ACID MIXING POT

THE POWER-GAS CORPORATION LTD.
STOCKTON-ON-TEES ENGLAND

SKETCH No. C 9021/3061/101/11

Fig. 13

Current Events

UNITED KINGDOM

Acid Plant Reconstruction

A large capital development scheme, to make use of American sulphur filter cake instead of imported Spanish pyrites, in the manufacture of sulphuric acid, will begin in a year's time at the Flixborough, Scunthorpe, works of Nitrogen Fertilisers Ltd. The use of Spanish pyrites will cease entirely and all but one of the existing pyrites furnaces at the works are to be dismantled.

The filter cake, as the name implies, results from the cleaning of contaminated Frasch sulphur. It contains an average of 70% sulphur, the balance being impurities such as ash, bitumen and organic matter. One of the principal advantages of this raw material is its low cost, believed to be £4-£5 per ton f.o.b.

Contracts for the plant and equipment have already been placed. The new converter unit, which will have a capacity of more than 50,000 tons of sulphuric acid a year, is to be built and installed by the Power-Gas Corporation Ltd., of Stockton -on-Tees.

An important feature of the plant will be a waste heat boiler, which has been designed by the company's own engineers and technologists, and is to be built by Messrs. Edgar Allen & Co. Ltd., of Sheffield.

Preparation of the site is not expected to interfere with normal production, though it is reported that, to enable the company's present fertiliser output to be maintained during the transitional period, outside purchase of some sulphuric acid will be necessary.

Once in production the new plant, which will be among the most modern in the world, is expected to increase the present output of sulphuric acid at Flixborough by about 20% and at the same time save between 4,000 and 5,000 tons of coal a year.

The Trentside factory of the company—the only producer of ammonium sulphate in the United Kingdom to convert synthetic nitrogen by the use of sulphuric acid, went into production fourteen years ago, and is now producing about 50,000 tons of ammonium sulphate a year.

CANADA

Recovered Sulphur

The programme of large scale production of sulphur recovered from natural gas has received a set-back following the announcement on 18th March that the Trans-Canada Pipe Lines' project has been shelved for a year. This decision resulted from the inability of the company to secure financial aid from the Government, and necessitated their application to the Alberta Petroleum and Natural Gas Conservation Board and the Federal Transport Commissioners to extend existing permits for one year from 30th April, 1955. Trans-Canada Pipe Lines are continuing their efforts to arrange for the necessary finance from private capital sources as their negotiations with the Industrial Development Bank also proved abortive due to the latter's inability, under the existing provisions of the Bank Act, to make loans to a gas pipe line company. The original project provides for the initial supply of 125 million cubic feet per day to feed the 2,250 mile pipe line from Alberta to Eastern Canada. It is estimated that this volume of gas under present supply facilities would lead to the recovery of at least 200 tons sulphur per day.

UNION OF SOUTH AFRICA

New Acid Plant

The sulphuric acid plant of the Virginia Orange Free Estate Gold Mining Company Limited, one of the seven new sulphuric acid plants serving the South

African uranium industry, is shortly to start operations. It will have a rated capacity of 330 tons per day acid (98.5%) and will thus be one of the largest in the world. Acid production will result from the use of sulphur in pyrites concentrates obtained from gold ore residue. It is envisaged that pyrites supplies will become available not only from the company's own mine, but also from Merriespruit (Orange Free State) Gold Mining Company Limited and Harmony Gold Mining Company Limited, whose activities in this field have received government approval during the last few months. Roasting of pyrites concentrates will be effected in three Dorr Fluosolids roasters with a total roasting capacity of 350 tons concentrate per twenty-four hours. These plants are designed to receive the ore feed in the form of an aqueous slurry of about 70% solids concentration. Conversion of sulphur dioxide gases will be effected in a contact plant using a vanadium catalyst.

U.S.A.

Freeport Sulphur Company

During the early part of March, production of sulphur started at the Company's new Chacahoula dome situated near Thibodaux, fifty miles west of New Orleans, in the Louisiana cypress swamps. The start of these operations completes the company's four-dome expansion programme which involved a capital expenditure of over $25 million over the past three years. The adverse location of the Chacahoula dome has given rise to considerable difficulties during the exploratory and construction stage which the company's engineers were able to overcome and complete the project according to schedule. The water and steam facilities are designed for an output of 200,000 tons sulphur per annum and the development was originally planned to make good the loss of production from the Company's failing Hoskins Mound.

Continental Sulphur and Phosphate Corporation

This company is operating the new sulphur refining plant at Sulphurdale, Utah, which was scheduled to start working in March this year. In this enterprise the company is associated with the American Sulphur and Refining Company, which developed and licensed the solvent refining process in use *(Quarterly Bulletin No. 6, p. 56).*

Before operations started, a substantial tonnage or sulphur ore was extracted. This ore originates from a surface deposit covered by an overburden of between two and ten feet and is obtained by strip mining. It contains an average of 20% sulphur, and extraction will be at the rate of over 500 tons per day to yield about 100 tons of refined, granulated sulphur. The results of the operations at the refining plant are awaited with much interest, as the plant is the first in the U.S.A. based on a solvent process to come into production.

Among other interests of the Continental Sulphur and Phosphate Corporation is a sulphur ore deposit in Wyoming, which is reported to contain ½-1½ million tons of elemental sulphur. Its exploitation is not at present contemplated but, if progress at Sulphurdale is satisfactory, a plant may be erected at the Wyoming property which is located near a good market.

Insoluble Sulphur

The Stauffer Chemical Company started operations of its new sulphur processing plant at Monongahela, Pennsylvania, in January of this year. The output of this allotropic form of sulphur under the trade name "Crystex" at existing plants at Chauncey, New York and Richmond, California, is insufficient to meet industrial demand, which the new plant is intended to remedy. Its proximity to large users in the rubber industry have determined the site of the new plant. The operation is based on continuous flow,

converting ordinary rhombic sulphur to the allotropic form. The Stauffer process involves rapid cooling of molten sulphur in carbon disulphide with the separation of insoluble polymerized allotropic sulphur, estimated to have a molecular weight of several hundred thousand.

Insoluble in all known solvents, "Crystex" may be used in formulations where ordinary sulphur would produce unwanted reactions. Reversion to the rhombic form can easily be accomplished by heating, permitting normal sulphur activity. This property of "Crystex" has resulted in its extensive use in the rubber industry where normal sulphur activity prior to curing results in undesirable "blooming." By contrast, insoluble sulphur remains inactive until the curing temperature causes normal vulcanisation. In the United Kingdom output of insoluble sulphur is increasing to meet growing demand.

DENMARK

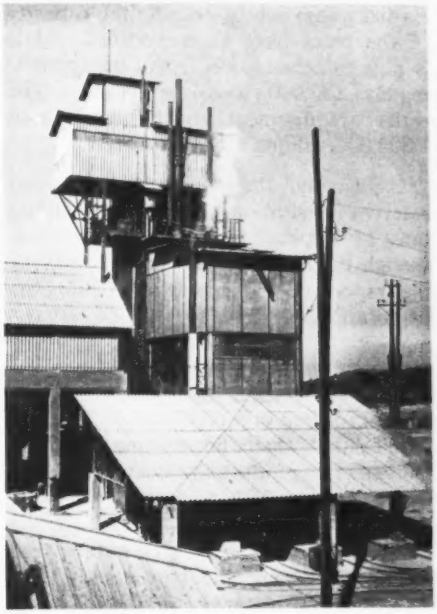
Recovered Sulphur Potential

At The Maersk Oil Refinery of Messrs. A. P. Moller at Copenhagen a new catalytic cracking plant has been installed recently. In the initial stages of operations no provision is made for the recovery of sulphur which arises in the form of hydrogen sulphide, and the sulphurous gas is to be flared. Recovery is, however, contemplated at a later date and if feed stock similar to that at present in use is employed, some 400-500 tons p.a. sulphur may be recovered. Danish industry does not at present consume any sulphur in elemental form, and it is to be assumed that any arising would be exported.

ITALY

Sulphur Refining Process

The sulphur refining plant built by Impianti Speciali per l'Industria at Perticara was scheduled to start final trial operations early in March this year. Earlier trials produced data of considerable importance, which have led to modifications of the plant, and the results of the latest tests are awaited with much interest. The plant is based on the Masobello process, which was developed to treat volcanic sulphur ores, specially those occurring in Italy and Sicily. It is based on the complete



General view of refining plant at Perticara.

distillation of the sulphur content of the ore, followed by condensation, the refined sulphur being produced in melted form. Details of the process are described in *Quarterly Bulletin No. 5.*

MEXICO

Gulf Sulphur Corporation

The Frasch sulphur project started by Gulf Sulphur Corporation—the third dome to be developed in Mexico—on the Chapas River at Las Salinas in 1953 is now making good progress. The undertaking is financed by private American capital, the three well-known Brady Brothers having the majority holding.

From an account received from the Corporation's Executive Vice-President, Stuart C. Dorman, it appears that the

construction of the power plant and principal buildings is about to start. A fourteen million gallon reservoir has been excavated and the barge canal from plant site to the river is almost finished. It is anticipated that construction will be completed by the middle of this year. Earlier estimates of the output capacity of the plant have been modified and it is now calculated that it will be approximately 150,000 tons per year. The water requirement will be about 1,300,000 gallons at 330°F. per day.

Recently, the company has found reserves in addition to the eleven million tons of sulphur previously announced, though the exact amount is still awaiting the report of the geologist making the exploration.

ECUADOR

Ecuadorian Mining Corporation

According to a recent account by the Corporation, their Tixan mine is in full commercial production. The rumours which appeared in a number of press reports last autumn that, due to the cessation of activities, the plant and mining property were about to revert to the Ecuadorian Government, are stated to be without any foundation. Domestic and export shipments have taken up the entire output for the next six months, and this is believed to be at the rate of about 4,000 tons per annum. An expansion programme is at present under consideration, and it is expected that output will be substantially higher in the very near future. The Corporation ship from the port of Duran, and their current export price is $42 per ton f.o.b.

IRAQ

Sulphur Concession

On January 21st Dr. Nadim Pachachi, the Minister of Economics, having informed the Finance Committee of the Chamber of Deputies of the Government's decision, published the following statement :—

> "The Iraq Government has refused to grant a foreign company—the Texas Gulf Sulphur Company—a concession for the exploitation of Iraq's sulphur deposits situated north of the 33rd parallel, because terms submitted by the company are insecure to Iraq's full rights."

Dr. Pachachi further stated that in order to secure full information regarding Iraq's deposits of sulphur and its commercial quality and quantity, the Government had decided to engage the services of a foreign expert of high standing to study the issue and to report the possibilities of "exploiting our own sulphur deposits."

In this connection the chief engineering adviser of the World Bank, Mr. B. Colquhoun, visited Bagdad in February, and it is believed that a detailed investigation by an expert geologist acting on behalf of the Government is to start shortly. Until his findings are available it is thought unlikely that the Government would give consideration to applications for a concession.

Following the final break in negotiations between the Iraqi Government and the Texas Gulf Sulphur Company, the latter is reported to have cancelled the registration of the ID 1 million company which they formed in Iraq in 1953, soon after starting their negotiations for a sulphur concession.

INDIA

New Sulphur Deposits

Ore deposits estimated to contain more than 200,000 tons sulphur have been located in Ladakh, Kashmir, according to the Indian Minister for Natural Resources and Scientific Research. The Bureau of Mines state that "the deposit could be worked economically only if proper communications were built."

Pyrites Discovery

The Geological Survey of India have discovered pyrites deposits, containing an average of 43% sulphur, in two areas of the Shababad district of Bihar. In recent years there has been no production in India of sulphuric acid from pyrites.

Statistical Appendix

United Kingdom

IMPORTS (thousand tons)

	Sulphur	Pyrites
1910	18	812
1920	26	631
1928	92	301
1938	131	401
1946	246	162
1947	305	175
1948	348	213
1949	392	230
1950	439	192
1951	377	348
1952	407	505
1953	197	385
1954	376	601

SULPHURIC ACID PRODUCTION
(thousand tons 100% H_2SO_4)

Average 1900-1919	1065
„ 1920-1929	858
„ 1930-1939	921
„ 1940-1945	1236
1946	1328
1947	1333
1948	1553
1949	1661
1950	1803
1951	1606
1952	1506
1953	1875
1954	2042

SULPHURIC ACID CONSUMPTION
(thousand tons 100% H_2SO_4)

	1953	1954
Accumulators	10.0	9.3
Agricultural Purposes	9.5	8.2
Bichromate and Chromic Acid	9.5	14.6
Bromine	15.9	21.9
Clays	9.2	10.5
Copper Pickling	3.7	2.7
Dealers	12.1	14.2
Drugs and Fine Chemicals	14.1	24.0
Dyestuffs and Intermediates	68.2	83.8
Explosives	31.8	32.1
Export	2.6	3.4
Glue	0.5	0.5
Hydrochloric Acid	54.3	60.3
Hydrofluoric Acid	11.9	12.0
Iron Pickling	96.5	108.5
Leather	4.2	4.8
Lithopone	11.9	15.6
Metal Extraction	4.0	4.3
Oil Refining and Petroleum Products	64.2	54.8
Oils (vegetable)	11.2	11.7
Paper, etc.	5.3	7.3
Phosphates (Industrial)	1.4	1.1
Plastics	21.1	28.8
Rayon and Transparent Paper	232.6	248.2
Sewage	11.2	11.1
Soap and Glycerine	30.7	47.7
Sugar Refining	0.6	0.6
Sulphate of Ammonia	287.3	290.3
Sulphates of Copper, Nickel, etc.	20.5	23.1
Sulphate of Magnesium	5.1	4.9
Superphosphate	482.4	457.1
Tar and Benzol	22.8	23.0
Textiles	21.5	20.5
Titanium Oxide	169.2	211.3
Unclassified	144.8	175.5
Total	1901.8	2047.7

O.E.E.C. - 1st Half 1954

Thousand Metric Tons

	PRODUCTION				*CONSUMPTION*			
	Native (x) & Recovered Sulphur	Sulphur in Pyrites	Other Forms	Total	Elemental Sulphur	Sulphur in Pyrites	Other Forms	Total
Austria	—	—	26.4	26.4	12.1	12.5	24.6	49.2
Belgium	0.2	—	1.3	1.5	20.8	89.6	65.1	175.5
Denmark	—	—	0.8	0.8	—	32.2	0.1	32.3
Eire	—	—	0.3	0.3	0.1	13.0	0.3	13.4
France	1.5	62.3	21.0	84.8	76.1	193.6	39.2	308.9
W. Germany	32.0	98.0	42.0	172.0	41.5	310.0	70.0	421.5
Greece	1.1 (x)	45.6	12.8	59.5	11.1	17.9	11.2	40.2
Italy	96.7 (x)	275.0	46.3	418.0	63.0	290.0	40.1	393.1
Netherlands	5.4	—	3.4	8.8	1.5	100.0	10.5	112.0
Norway	51.6	108.7	1.6	161.9	13.0	22.9	9.4	45.3
Portugal	8.5	131.8	—	140.3	6.0	16.1	—	22.1
Sweden	12.6	104.0	15.3	131.9	29.6	125.0	—	154.6
Switzerland	—	—	0.4	0.4	16.5	12.0	0.1	28.6
Turkey	4.9 (x)	5.2	0.3	10.4	4.9	5.2	0.3	10.4
U.K.	19.2	0.9	192.2	212.3	187.4	124.0	223.5	534.9
	233.7	831.5	364.1	1429.3	483.6	1364.0	494.4	2342.0

United States

SULPHUR EXPORTS—1954

	Long Tons		*Long Tons*
Canada	292,375	Spain	2,969
Cuba	14,250	French Morocco	7,000
Mexico	754	Algeria	11,419
N. Antilles	13,300	Tunisia	13,000
Dominican Rep.	39	Egypt	246
Venezuela	1,069	U. of South Africa	67,000
Brazil	81,412	Israel	1,000
Argentina	9,842	Aden	442
Uruguay	4,921	Saudi Arabia	238
Paraguay	191	Iraq	693
Peru	49	Pakistan	822
United Kingdom	409,208	India	69,825
Belgium	48,500	Hong Kong	300
France	176,430	Australia	167,838
W. Germany	35,500	New Zealand	122,135
Switzerland	53,870	Indonesia	6,310
Austria	29,495	Philippine Rep.	3,600
Yugoslavia	909	Others	60
		Total	1,647,011

SULPHUR CONSUMPTION—1954

Sulphuric Acid Uses :	%	*Non-Acid Uses :*	%
Fertilisers	33	Pulp	7½
Chemicals	18½	Ground and Refined	5
Titanium and other pigments	7½	Carbon disulphide	4½
Iron and Steel	7	Other Chemicals and Misc.	3
Rayon and Film	4½		
Petroleum	3		
Other	6½		

Total Usage :

Elemental Sulphur	4.15	million tons
Sulphur in Pyrites, Smelter gases, etc.	.95	„ „
	5.1	„ „

Chile

SULPHUR EXPORTS—1954

	Metric Tons
France	15,877
W. Germany	1,012
Holland	1,000
Peru	153
Brazil	120
Argentine	23
Total	18,185
Total 1953	16,363

Japan

PYRITES PRODUCTION

	Pyrites.	*S. Content.*
	Thousand metric tons.	
1941 (pre-war peak)	2,106	918
1945 (post-war low)	404	178
1949	1,542	633
1950	1,929	803
1951	2,351	938
1952	2,628	1,053
1953	2,343	979
1954	2,345	980

ECUADORIAN
MINING CORPORATION

PRODUCERS AND REFINERS OF

SULPHUR

SHIPMENT IN BULK OR BAGS

Sole Distributors:

INTERNATIONAL
SULPHUR CORPORATION

P.O. BOX 2379, PANAMA CITY, RP

JEFFERSON LAKE
SULPHUR COMPANY

SULPHUR PRODUCERS

99.5 PER CENT. PLUS PURITY
(FREE OF ARSENIC, SELENIUM AND TELLURIUM)

Mines and Plants Located at:

Clemens Dome, Brazoria County, Texas.
Long Point Dome, Ford Bend County, Texas.
Starks Dome, Calcasieu Parish, Louisiana.
Manderson Field: Manderson, Wyoming.

General Offices:

1408 WHITLEY BUILDING
NEW ORLEANS 12, U.S.A.

MEXICAN GULF SULPHUR COMPANY

U.S. OFFICES:
630, Fifth Avenue,
New York 20, New York.
CABLEADDRESS: MEXSULF NEW YORK.

SUBSIDIARY:
Compania Azufrera Mexicana, S.A.,
(MEXICAN SULPHUR CO., S.A.)
Paseo de la Reforma 122,
Mexico 6, D.F.

S.S. Centaur loading Sulphur for the United Kingdom

FIRST producer of Frasch Process Sulphur outside the United States.

FIRST producer from Mexico's Isthmus of Tehuantepec.

NEW dock facilities available at Coatzacoalcos, Mexico for large scale export shipments to all countries of the world.

BIDDLE, SAWYER & CO., LTD.

invite your enquiries for

Industrial Chemicals and Raw Materials.

We can offer certain materials from our world stocks and others for shipment directly from origin to destination required.

BIDDLE, SAWYER & CO., LTD.

INDUSTRIAL CHEMICALS DIVISION
4, GRAFTON STREET, LONDON, W.1.

Telephone: **Hyde Park 0521** *Telegrams:* **Bidsawya, Piccy London** *Cables:* **Bidsawya, London**
International Telex No. **LONDON 8266/7**

Associated companies and offices throughout the world.